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Tables of Dielectric Materials

Volume IV

Technical Report No. 57
Laboratory for Insulation Research
Massachusetts Institute of Technology

January, 1953

TABLES OF DIELECTRIC MATERIALS
VOLUME IV

Laboratory for Insulation Research
Massachusetts Institute of Technology
Cambridge, Massachusetts

O. N. R. Contracts N5cri-07801
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January, 1953

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Tables of Dielectric Materials

Volume IV

Laboratory for Insulation Research
Massachusetts Institute of Technology
Cambridge, Massachusetts

About five years have passed since Volume III of the "Tables of Dielectric Materials" was issued. The world situation appeared to quiet down at that time, and we hoped to concentrate the whole activity of this laboratory on fundamental research in the field of dielectrics (polarization, magnetization and conduction). The outbreak of the Korean War found our country again unprepared and demonstrated with expensive clarity that we have to live on the alert for the rest of our lives. In consequence, the laboratory felt bound to retain the practical task assumed in World War II of acting as a clearing house for dielectric materials and their uses. One aspect of this activity is our long-range applied research program of tailoring dielectrics to order for specific applications. This work is concentrated at the present time on the problem of shaping the hysteresis loops of ferroelectrics and of ferromagnetic semiconductors to the requirements of the electrical engineer concerned with the development of memory systems, dielectric and magnetic amplifiers and other nonlinear devices. A second aspect is the "Tables of Dielectric Materials."

The "Tables" in their present form summarize the measurements of this laboratory on the complex permittivity (dielectric constant and loss tangent) and the complex permeability of important dielectrics made in this country. They are intended to aid government agencies, engineers and manufacturers in the proper application of dielectrics and in the development of better products. Volume IV reports on about 250 new materials; simultaneously, it has taken over and amplified the measurements given in the previous volumes as far as they still are of special interest. A number of materials now not in produc-

tion have been retained for this reason but are indicated as "discontinued." The total number of materials included amounts to over 600.

The selection of these materials was undertaken with the full co-operation of the manufacturers concerned. The laboratory measures any important new material free of charge for inclusion in the "Tables" if the manufacturer supplies all additional essential information. If some of this information is "confidential," it is locked away in our files and will be made available only after release by the manufacturer.

We are fully aware that these data should be expanded, especially towards higher temperatures and frequencies. Furthermore, additional measurements on d.c. conductivity, breakdown strength and other electric parameters would be of great value, and a presentation of the materials as in Volume III, where the dielectric characteristics of each individual dielectric have been plotted and essential information given on composition, properties, methods of handling and recommended uses. Finally, a real "dielectric analysis" of the materials should be undertaken, linking their dielectric response to composition and molecular structure. We have to ask for the indulgence of the users of these "Tables" on these scores; ultra posse nemo obligatur, or, in free translation, our budget is already stretched to the breaking point by our present obligations.

Volume IV does not contain our more extensive measurements on ferroelectrics and ferromagnetics. These data on nonlinear dielectrics will be issued in a separate Volume V as soon as they are reasonably complete.

The measurements were made by W. B. Westphal, group leader of our dielectric measurements group, who was ably supported by three staff operators: Helen M. Dunn, Patricia A. Fergus and Elizabeth McCarty. Invaluable help in the editing and correcting of the manuscript was given by Harriet B. Armstrong.

This work was sponsored under our O.N.R. contracts jointly by the Navy Department (Office of Naval Research), the Army Signal Corps and the Air Force

(Air Materiel Command); we thank all three Services for their understanding
and co-operation.

von Hippel, Director
Laboratory for Insulation Research

Dielectric Parameters

1. ϵ' , the dielectric constant or permittivity relative to vacuum, also designated in the literature as K, κ , ϵ , D.C., etc.
2. $\tan \delta$ or $\tan \delta_d$, the dielectric loss tangent or dissipation factor, also designated in the literature as D.F., $1/Q$, and when losses are low, as power factor or $\cos \theta$.
3. μ' , the magnetic permeability relative to vacuum, also given in the literature as μ' or μ_0 .
4. $\tan \delta_m$, the magnetic loss tangent.
5. ρ , the a.c. volume resistivity in ohm cm. This parameter is used in these tables only for very high-loss materials.

Transformation to other parameters. The dielectric loss factor relative to vacuum, ϵ''/ϵ_0 , is the product of the dielectric loss tangent and ϵ'/ϵ_0 . A.c. volume conductivity, σ , is given by

$$\sigma = \frac{1}{\rho} = \frac{f(\epsilon'/\epsilon_0) \tan \delta}{1.8 \times 10^{12}} \quad [\text{mho cm.}] \quad (f \text{ in c/s})$$

A chart is given (page x) for approximate calculations of σ or ρ from the data given in the tables.

The magnetic loss factor relative to vacuum, μ''/μ_0 , is the product of the magnetic loss tangent and μ'/μ_0 (in analogy to the dielectric loss factor). In the literature, the loss factor is sometimes given as $\frac{1}{\mu_0' Q}$ or in our notation, $\tan \delta_m / (\mu'/\mu_0)$.

The attenuation constant, α , for propagation in free space is

$$\frac{2\pi}{\lambda_0} \left[\frac{\mu' \epsilon'}{\mu_0 \epsilon_0} \frac{1 - \tan \delta_d \cdot \tan \delta_m}{2} \left(\left[1 + \tan^2(\delta_d + \delta_m) \right]^{1/2} - 1 \right) \right]^{1/2},$$

which for nonmagnetic dielectrics reduces to

$$\frac{2\pi}{\lambda_0} \left(\frac{\epsilon'}{\epsilon_0} \right)^{1/2} \left[\frac{\left(1 + \tan^2 \delta_d \right)^{1/2} - 1}{2} \right]$$

Charts for finding α in terms of ϵ'/ϵ_0 and $\tan \delta_d$ are included in this report (pages xi-xiii). They apply also to magnetic dielectrics when the product $(\mu'/\mu)(\epsilon'/\epsilon_0)$ is substituted for ϵ'/ϵ_0 and an equivalent combined loss tangent $\tan \delta_e$ is used instead of $\tan \delta_d$. A graph is given (page xiv) showing $\tan \delta_e$ for values of $\tan \delta_d$ and $\tan \delta_m$ in the range 0.1 to 10. For smaller values, $\tan \delta_e = \tan \delta_d + \tan \delta_m$.

The phase constant β for propagation in free space is

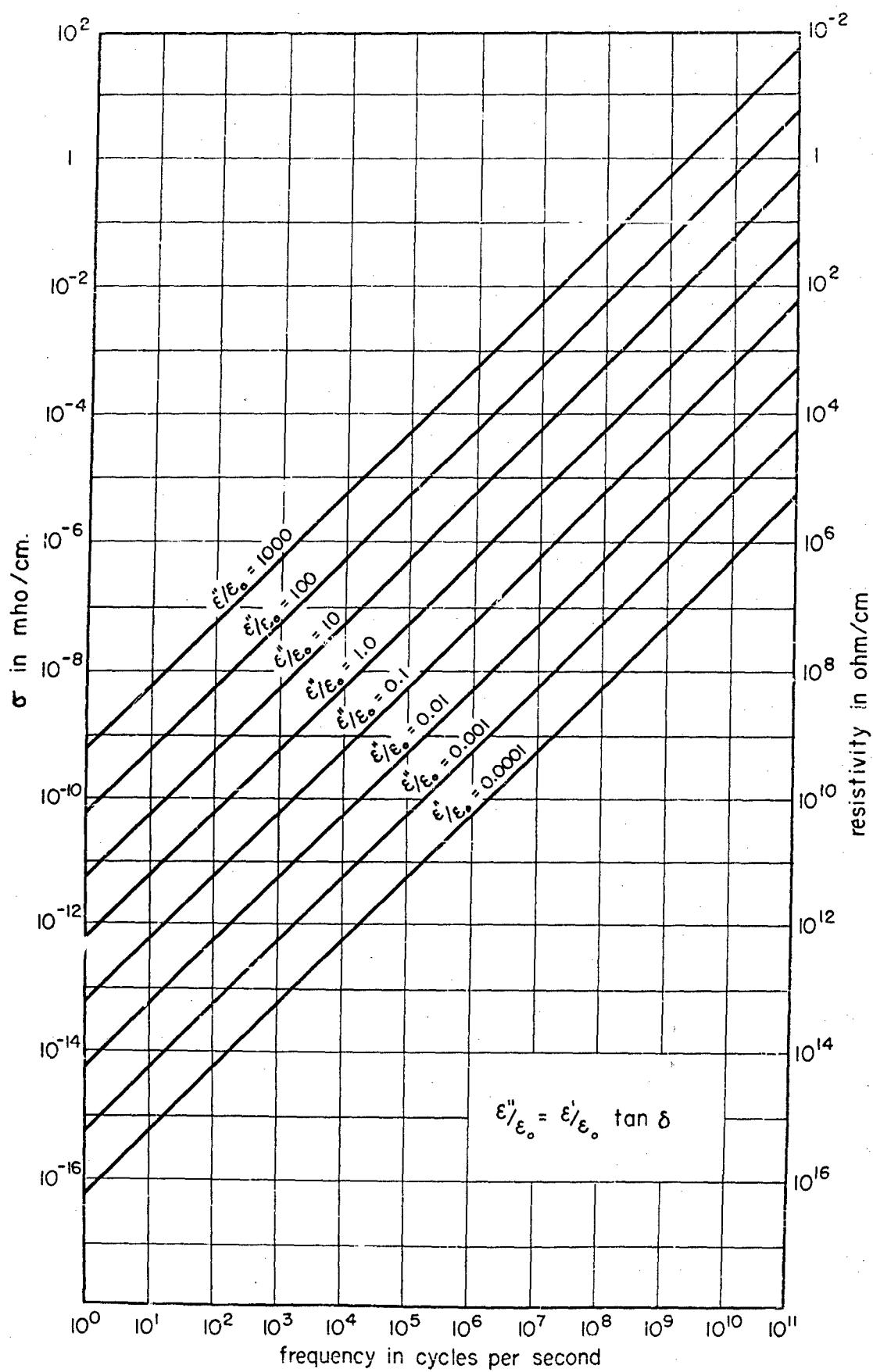
$$\frac{2\pi}{\lambda_0} \left[\frac{\mu' \epsilon'}{\mu_0 \epsilon_0} - \frac{1 - \tan \delta_d \cdot \tan \delta_m}{2} \left(\left[1 + \tan^2(\delta_d + \delta_m) \right]^{1/2} + 1 \right) \right]^{1/2},$$

which reduces for nonmagnetic materials to

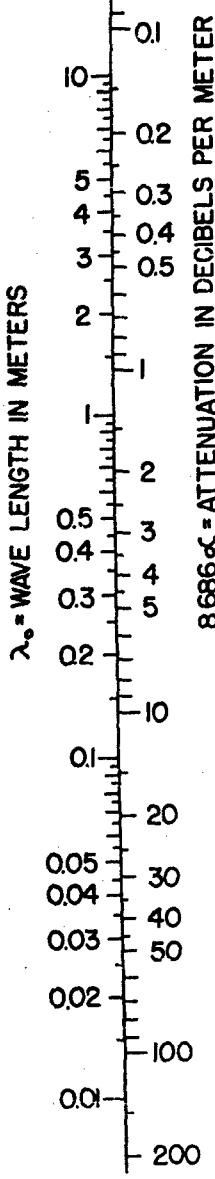
$$\frac{2\pi}{\lambda_0} \left(\frac{\epsilon'}{\epsilon_0} \right)^{1/2} \left[\frac{\left(1 + \tan^2 \delta_d \right)^{1/2} + 1}{2} \right]^{1/2}.$$

The intrinsic impedance Z of the material is

$$377 \left(\frac{\mu^* \epsilon_0}{\mu_0 \epsilon^*} \right)^{1/2}.$$



Conductivity-resistivity as function of ϵ''/ϵ_0 and frequency.

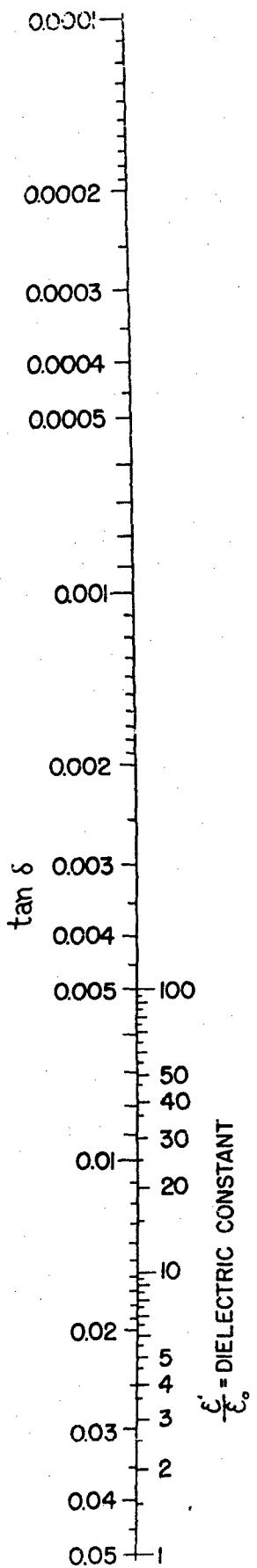
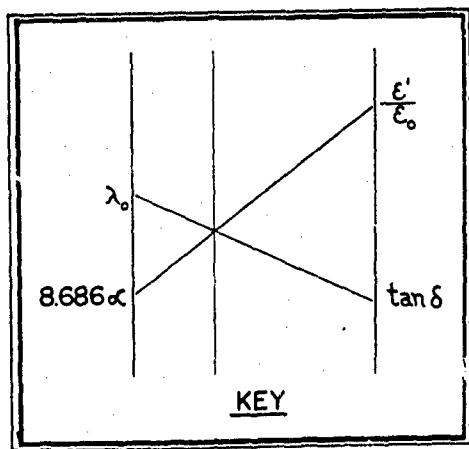


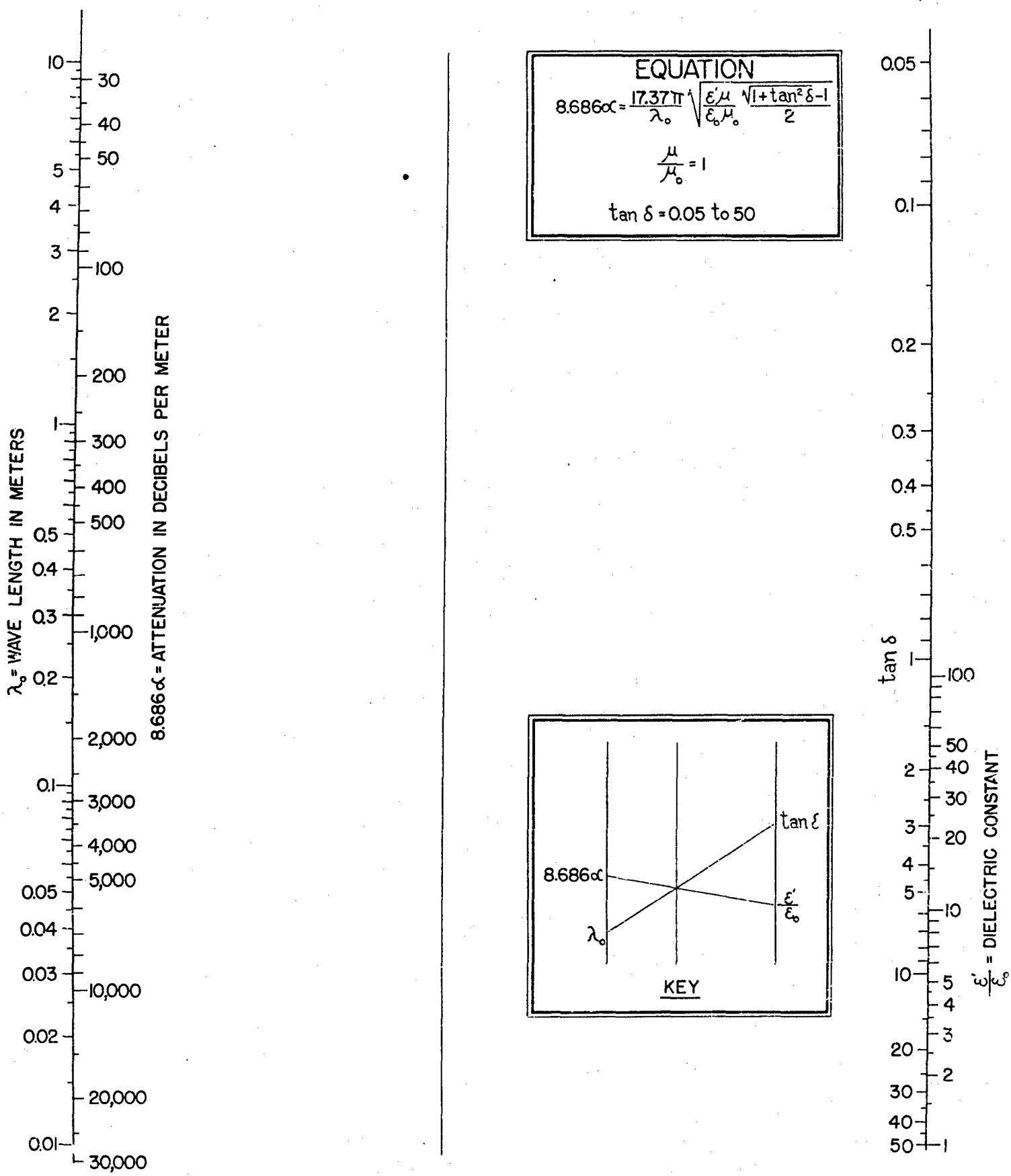
EQUATION

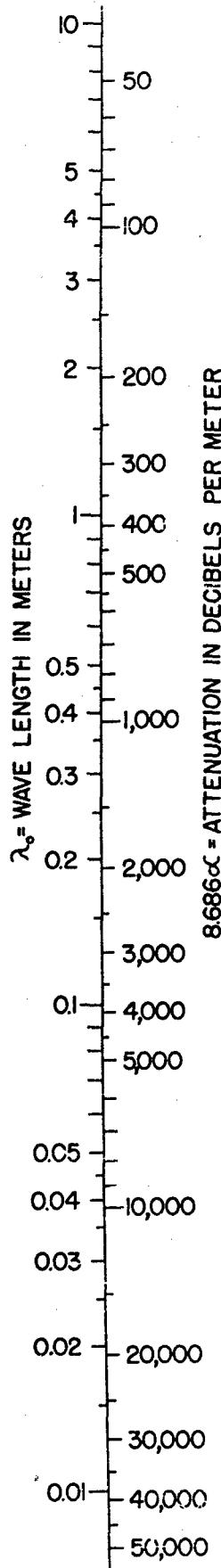
$$8.686\alpha = \frac{8.636 \cdot \pi \cdot \tan \delta}{\lambda_0} \sqrt{\frac{\epsilon' \mu}{\epsilon_0 \mu_0}}$$

$$\frac{\mu}{\mu_0} = 1$$

$$\tan \delta = 0.0001 \text{ to } 0.05$$





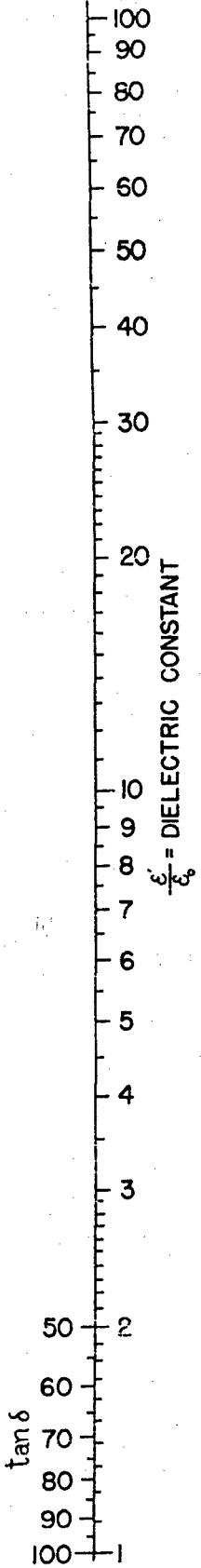
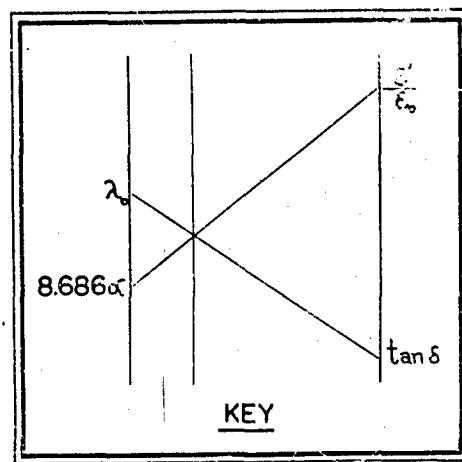


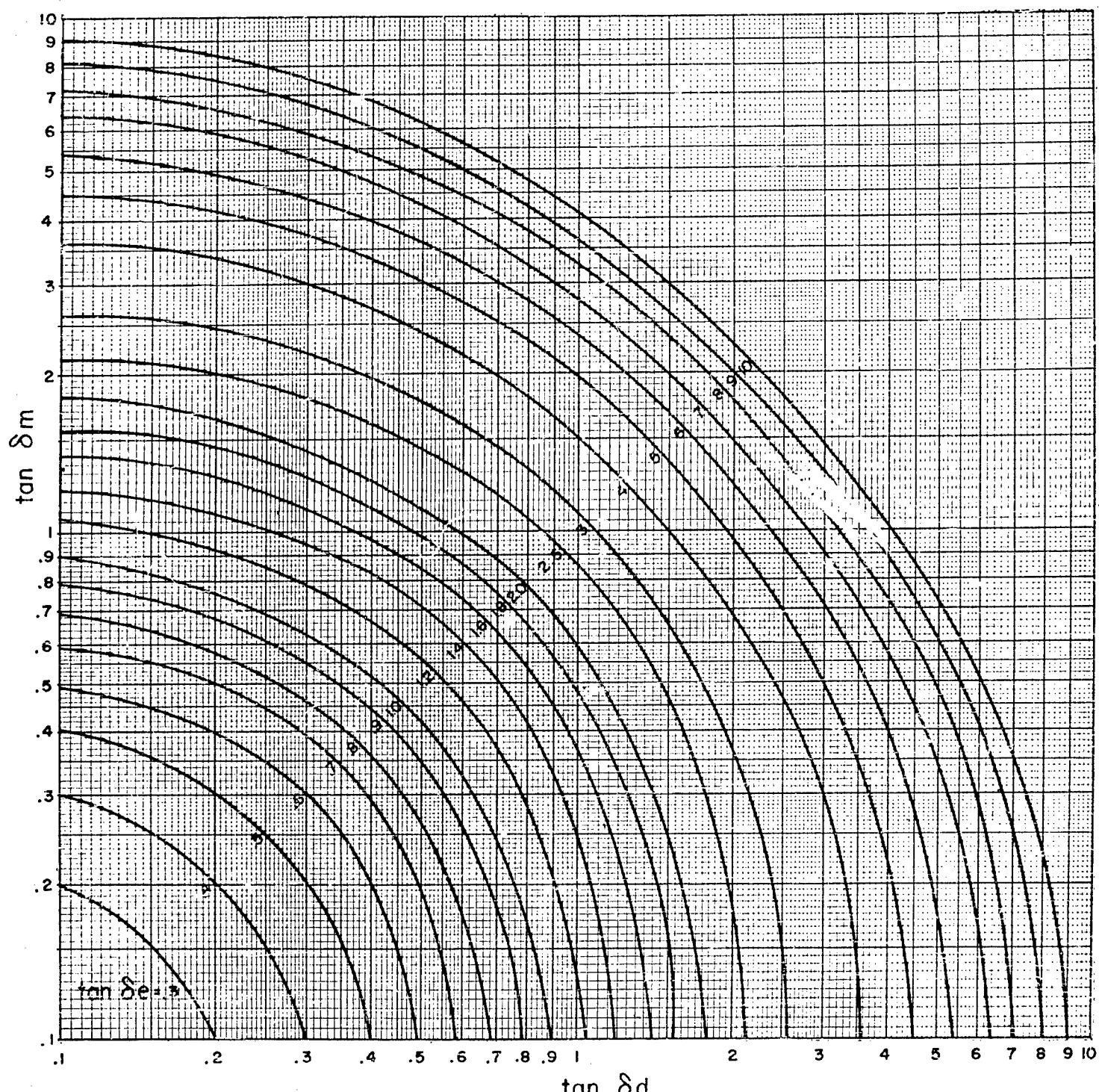
EQUATION

$$8.686\alpha = \frac{17.37\pi}{\lambda_0} \sqrt{\frac{\epsilon'\mu}{\epsilon_0\mu_0}} \frac{\tan\delta}{2}$$

$$\frac{\mu}{\mu_0} = 1$$

$$\tan\delta = 50 \text{ to } 100$$





Equivalent loss tangent of magnetic materials.

Measurements and Accuracy

The measurements have been made, in general, on only one batch of the material and refer, unless otherwise specified, to samples dried over phosphorous pentoxide. Due to the wide variety of materials and improvements in techniques, no figures of general validity can be given concerning the accuracy of these measurements. For ϵ'/ϵ_0 , the nominal accuracy is $\pm 2\%$; the accuracy trends are toward $\pm 1\%$ for rigid, low-loss materials ($\tan \delta < 0.005$) and $\pm 5\%$ for high-loss materials ($\tan \delta > 1$). For $\tan \delta_d$, the nominal accuracy is $\pm 5\%$; for high-loss materials, the error may be $\pm 10\%$. For very low-loss materials ($\tan \delta < 0.002$), the accuracy is ± 0.0001 when the losses are given as multiples of 0.0001. When the loss is expressed in multiples of 0.00001, the error may be ± 0.00003 . For μ'/μ_0 , the nominal accuracy is $\pm 5\%$, for $\tan \delta_m$, $\pm 10\%$.

Field strengths. The linear dielectrics, those normally not field-strength sensitive, were measured at field strengths of approximately 50 volts per cm. in the frequency range 10^2 to 10^8 c/s and at lower field strengths at higher frequencies. At high temperatures (near 500°C) many of these materials show field-strength sensitivity, particularly at low frequencies. The effects may be wholly or partly due to space charge polarization.

The ferroelectric and ferromagnetic materials, unless otherwise noted, were measured at field strengths in their linear region. The values thus measured are the initial permittivity and permeability. Typical field strengths are 40 volts/cm. for titanate ceramics, 0.01 volts/cm. for KDP crystals, 0.01 oersteds for the ferrites.

I. SOLIDS
Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

A. Inorganic	$T^{\circ}\text{C}$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{1x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$
1. Crystals											
Ice ^a	-12	ϵ'/ϵ_0	-----	4.8	4.15	3.7	---	---	3.20	3.17	
Snow ^b	-20	ϵ'/ϵ_0	-----	8000	1200	180	---	---	9	7	
Snow ^c	-6	ϵ'/ϵ_0	-----	3.33	1.82	1.24	1.20	1.20	1.20	1.20	1.26*
Aluminum oxide, sapphire ^d	25	ϵ'/ϵ_0	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
(field \perp optical axis)		$\tan \delta$	< 10	< 2	< 10	< 10	< 10	< 10	< 1	---	---
(field \parallel optical axis)		ϵ'/ϵ_0	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55
Ammonium dihydrogen phosphate (field \perp optical axis) ^e	25	ϵ'/ϵ_0	56.4	56.0	55.9	55.9	55.9	55.9	55.9	55.9	55.9
(field \parallel optical axis)		ϵ'/ϵ_0	400	46	4.6	< 5	< 5	< 5	< 5	< 10	
Lithium fluoride ^f	25	ϵ'/ϵ_0	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
		$\tan \delta$	15	< 3	< 2	< 2	< 2	< 2	---	.7	1.8
		ϵ'/ϵ_0	9.11	9.11	9.11	9.11	9.11	9.11	---	---	9.11
Magnesium oxide ^g	25	ϵ'/ϵ_0	9.65	9.65	9.65	9.65	9.65	9.65	9.65	9.65	9.65
		$\tan \delta$	< 3	< 3	< 3	< 3	< 3	< 3	< 3	---	50
Potassium bromide ^f	25	ϵ'/ϵ_0	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90
		$\tan \delta$	7	7	8	4.5	< 2	< 2	< 1	---	2.3
Potassium dihydrogen phosphate (field \perp optical axis) ^g	25	ϵ'/ϵ_0	44.5	44.3	44.3	44.3	44.3	44.3	44.3	44.3	44.3
(field \parallel optical axis)		$\tan \delta$	98	15	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Selenium, multi-crystal-line ^h	25	ϵ'/ϵ_0	21.4	20.7	20.5	20.3	20.2	20.2	20.2	20.2	20.2
		$\tan \delta$	170	24	< 20	< 5	< 5	< 5	< 5	< 5	< 5

a. From conductivity water. b. Freshly fallen snow. c. Hard-packed snow followed by light rain. d. Linde Air. e. Brush.

f. Fresh crystals (Harshaw). g. Norton. h. Lab. Ins. Res.

* -6°C.

I. Solids. A. Inorganic.
1. Crystals (cont.)

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

	$T^{\circ}C$	ϵ'/ϵ_0	$\frac{1x10^2}{}$	$\frac{1x10^3}{}$	$\frac{1x10^4}{}$	$\frac{1x10^5}{}$	$\frac{1x10^6}{}$	$\frac{1x10^7}{}$	$\frac{1x10^8}{}$	$\frac{1x10^9}{}$	$\frac{1x10^{10}}{}$	$\frac{2.5x10^{10}}{}$
Sodium chloride ^a	25	ϵ'/ϵ_0	$\frac{1x10^2}{5.90}$	$\frac{1x10^3}{5.90}$	$\frac{1x10^4}{5.90}$	$\frac{1x10^5}{5.90}$	$\frac{1x10^6}{5.90}$	$\frac{1x10^7}{5.90}$	$\frac{1x10^8}{5.90}$	$\frac{1x10^9}{5.90}$	$\frac{1x10^{10}}{5.90}$	$\frac{2.5x10^{10}}{5.90}$
		$\tan \delta$	< 1	< 1	< 1	< 2	< 2	< 2	< 2	< 2	< 2	< 5
Sulfur ^b (100)	85	ϵ'/ϵ_0	6.35	6.11	6.00	5.98	5.98	5.98	5.98	5.98	5.98	5.97
		$\tan \delta$	170	240	70	6	< 2	< 2	< 2	< 2	< 2	< 3.9
(010)	25	ϵ'/ϵ_0	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
		$\tan \delta$	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
(001)	25	ϵ'/ϵ_0	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
		$\tan \delta$	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Sulfur, sublimed ^c	25	ϵ'/ϵ_0	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.62
		$\tan \delta$	3	2	2	2	2	2	2	2	2	3.58
Thallium bromide ^d	25	ϵ'/ϵ_0	31.1	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3
		$\tan \delta$	1300	128	13.3	13.3	2	1	1	1	1	1.5
Thallium iodide ^d	25	ϵ'/ϵ_0	22.3	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8
		$\tan \delta$	950	120	12	1.2	.5	.5	.5	.5	.5	.5
193	193	ϵ'/ϵ_0	----	----	----	----	----	----	----	----	37.3	37.3
		$\tan \delta$	----	----	----	----	----	----	----	----	820	820
Thallium bromide - chloride ^{d,e}	25	ϵ'/ϵ_0	32.9	32.0	32.0	31.8	31.8	31.8	31.8	31.8	31.8	31.8
		$\tan \delta$	4500	441	46	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Thallium bromide - iodide ^{d,f}	25	ϵ'/ϵ_0	32.9	32.8	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
		$\tan \delta$	29800	2800	277	37	4	4	4	4	4	4
Titanium dioxide, rutile ^g (Field \perp optical axis) (Field \parallel optical axis)	25	ϵ'/ϵ_0	87.3	86.7	86.4	86	85.8	85.8	85.8	85.8	85.8	85.8
		$\tan \delta$	110	32	9	4	2	2	2	2	2	2
	25	ϵ'/ϵ_0	----	----	200	170	170	170	170	170	170	170
		$\tan \delta$	----	----	3500	600	600	600	600	600	600	600

a. Fresh crystals (Harslawn). b. Measured with field \perp to cuts indicated. Grown at Lab. Ins. Res. c. U.S.P. d. Grown at Eng. Res. and Dev. Lab., Fort Belvoir, Va. e. KRS-6, 60% ThBr, 40% ThCl. f. KRS-5, 42% ThBr, 58% ThI. g. Linde Air.

I. Solids, A. Inorganic

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

2. Ceramics	$\frac{1}{T}^{\circ}\text{C}$	$\frac{1x10^2}{\epsilon' / \epsilon_0}$	$\frac{1x10^3}{\epsilon' / \epsilon_0}$	$\frac{1x10^4}{\epsilon' / \epsilon_0}$	$\frac{1x10^5}{\epsilon' / \epsilon_0}$	$\frac{1x10^6}{\epsilon' / \epsilon_0}$	$\frac{1x10^7}{\epsilon' / \epsilon_0}$	$\frac{1x10^8}{\epsilon' / \epsilon_0}$	$\frac{1x10^9}{\epsilon' / \epsilon_0}$	$\frac{1x10^{10}}{\epsilon' / \epsilon_0}$	$\frac{2.5x10^{10}}{\epsilon' / \epsilon_0}$
a. Steatite Bodies											
AlSiMag A-35 ^a	23	ϵ' / ϵ_0	6.10	5.96	5.89	5.86	5.84	5.80	5.75	5.60	5.36
		tan 8	150	100	70	50	38	35	37	41	58
	85	ϵ' / ϵ_0	6.84	6.37	6.11	5.96	5.86	5.80	5.75	5.50	
		tan 8	890	370	175	103	77	50	50		
AlSiMag A-196 ^a	25	ϵ' / ϵ_0	5.90	5.88	5.84	5.80	5.70	5.65	5.60	5.42	5.18
		tan 8	30	59	79.5	55	30.5	19	16	18	38
	81	ϵ' / ϵ_0	5.90	5.88	5.84	5.80	5.70	5.65	5.60	5.42	-
		tan 8	58	40	46.5	70.5	66	40.5	24	18	
AlSiMag 211 ^a	25	ϵ' / ϵ_0	6.00	5.98	5.98	5.97	5.97	5.96	5.96	5.96	
		tan 8	92	34	12	6	5	4	4	4	
AlSiMag 228 ^a	25	ϵ' / ϵ_0	6.40	6.40	6.40	6.40	6.36	6.30	6.20	5.97	5.83
		tan 8	15.6	20	20	15.6	12.4	11.2	10	13	42
	81	ϵ' / ϵ_0	6.52	6.46	6.40	6.40	6.36	6.30	6.30	5.95	
		tan 8	35.6	22	18	21.5	18.4	11.8	11.8	11	
AlSiMag 243 ^a	22	ϵ' / ϵ_0	6.30	6.30	6.28	6.25	6.22	6.17	6.10	5.78	5.76
		tan 8	12.5	4.5	4.0	< 9	3.7	3.5	3	6	8.5
	85	ϵ' / ϵ_0	6.37	6.37	6.37	6.36	6.32	6.28	6.28	5.88	
		tan 8	21	13.7	8.0	< 9	3.7	3.5	3.5	6	
AlSiMag 393 ^b	24	ϵ' / ϵ_0	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.91
		tan 8	38	23	16	12	10	10	10	10	
Ceramic F-66 ^c	25	ϵ' / ϵ_0	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.2
		tan 8	14.5	9	5	2	1	1.5	3	5.5	11
Steatite Type 302 ^d	25	ϵ' / ϵ_0	5.80	5.80	5.80	5.80	5.80	5.80	5.80	5.8	5.8
		tan 8	32	20	16	13	12	12	12	19	36
Steatite Type 400 ^d	25	ϵ' / ϵ_0	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.5	5.5
		tan 8	160	100	72	60	50	45	39	39	53
Steatite Type 410 ^d	25	5.77	5.77	5.77	5.77	5.77	5.77	5.77	5.77	5.7	5.7
		tan 8	55	30	16	9	7	6	6	8.9	22
Steatite Type 452 ^d	25	ϵ' / ϵ_0	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15
		tan 8	65	28	17	12	10	10	10	20	31

a. Magnesium silicate (Am. Lava). b. 93% Al_2O_3 . 6% SiO_2 . 1% MgO (Am. Lava). c. 60% talc, 15% kaolin, 17.5% BaCO_3 , 7.5% MgCO_3 (Bell). d. Centrelab.

I. Solids, A. Inorganic (cont.)

2. Ceramics (cont)		Values for tan δ are multiplied by 10^4 ; frequency given in c/s.										
a. Steatite Bodies (cont.)		$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$	
Steatite Body 729 ^a	25	ϵ' / ϵ_0	6.55	6.55	6.54	6.53	6.53	6.53	6.53	6.53	6.52	6.51
		tan δ	14	7	4.8	3.9	4.9	5.2	6.2	6.8	9	10.9
Crolite #29 ^b	24	ϵ' / ϵ_0	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	5.90	5.71
		tan δ	25	19	15	13	11	10	----	----	24	30
b. Titania and Titanate Bodies												
Ceramic MPOT96 ^c	25	ϵ' / ϵ_0	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	28.9
		tan δ	12	4.9	3.3	2.5	1.6	1.7	2	---	---	20
Ceramic N750T96 ^c	25	ϵ' / ϵ_0	83.4	83.4	83.4	83.4	83.4	83.4	83.4	83.4	83.4	83.4
		tan δ	5.7	4.5	3.5	2.5	2.2	2.3	4.6	4.6	4.6	14.6
Ceramic N1400T110 ^c	25	ϵ' / ϵ_0	131	130.8	130.7	130.5	130.2	130.2	130.0	130.0	130.0	130.0
		tan δ	6.7	5.5	3.3	1.4	3.0	5.5	7.0	7.0	7.0	7.0
Body T106 ^c	25*	ϵ' / ϵ_0	1518	1508	1480	1480	1480	1480	1480	1480	1480	1480
		tan δ	31	87	99	99	99	99	99	99	99	99
25** ϵ' / ϵ_0	1308	1280	1260	1245	1232	1220	1210	1210	1210	1210	1210	1210
		tan δ	98	120	140	100	85	150	420	420	420	420
Ti Pure R-200 ^d	26	ϵ' / ϵ_0	100	100	100	100	100	100	100	100	100	100
		tan δ	23	15	6.2	4	3	2.5	2.5	2.5	2.5	2.5
78 ϵ' / ϵ_0	97.5	97.5	97	97	97	97	97	97	97	97	97	97
		tan δ	130	60	33	13	4.5	2.3	2.3	2.3	2.3	2.3
Tin Tiicon T-J, T-L and T-M ^e	24	ϵ' / ϵ_0	96	96	96	96	96	96	96	96	96	96
		tan δ	8	4.5	2	1	2	3	3	3	3	3
78 ϵ' / ϵ_0	90	89	88.5	88	87.5	87	87	87	87	87	87	87
		tan δ	55	16	4	4	4	4	4	4	4	4
Tin Tiicon MC ^f	25	ϵ' / ϵ_0	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9
		tan δ	15	11	9	7	4	4	5	5	5	5

a. Gen. Ceramics and Steatite. b. Al_2O_3 , SiO_2 , MgO , CaO , BaO (Crowley). c. Amer. Lava. d. Rutile (Dupont, fired at Lab. Ins. Res.). e. Rutile (Titanium Alloy, fired at Lab. Ins. Res.). f. Magnesium titanate (Titanium Alloy, fired at Lab. Ins. Res.).

* .. 3/4" Disk. ** 0.2" disk cut from 3/4" disk.

I. Solids, A. Inorganic (cont.)

2. Ceramics (cont.)
b. Titania and titanate
bodies (cont.)

	$\frac{1}{T^{\circ}C}$	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\tan \delta}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\tan \delta}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\tan \delta}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^9}{\tan \delta}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$	$\frac{2.5 \times 10^{10}}{\tan \delta}$
Titania Ceramic ^a	25	ϵ' / ϵ_0	----	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	3×10^9	1×10^{10}	2.5×10^{10}
Titania Ceramic ^b	25	ϵ' / ϵ_0	----	----	----	33	5.2	----	60.5	----	60
Titania Ceramic ^b	25	ϵ' / ϵ_0	----	----	----	----	----	8.3	----	11	11
Tan Ticon C ^c	25	ϵ' / ϵ_0	167.8	167.7	167.7	167.7	167.7	167.7	166.8	165	165
Tan Ticon S ^d	82	ϵ' / ϵ_0	157	156	156	156	156	156	156	155	155
Tan Ticon S ^d	25	ϵ' / ϵ_0	234	233	232	232	232	232	232	232	230
Tan Ticon B ^e	25	ϵ' / ϵ_0	1240	1200	1170	1153	1143	1140	1140	1140	1140
Tan Ticon BS ^f	25	ϵ' / ϵ_0	8700	8500	8200	8100	8000	8000	8000	8000	8000
(discontinued)											
Mix 71 BaTiO ₃ ^g	25	ϵ' / ϵ_0	1740	1720	1680	1650	1650	1650	1650	1650	1650
Mix 72 BaTiO ₃ ^g	25	ϵ' / ϵ_0	1310	1310	1300	1280	1280	1280	1280	1280	1280
SrTiO ₃ 10%											
Mix 73 BaTiO ₃ 80% ^g	25	ϵ' / ϵ_0	2163	2163	2120	2020	2020	1960	1960	1960	1960
SrTiO ₃ 20%											
Mix 74 BaTiO ₃ 70.9% ^g	25	ϵ' / ϵ_0	2990	2970	2910	2840	2840	2820	2820	2820	2820
SrTiO ₃ 29.1%											
Mix 75 BaTiO ₃ 60% ^g	25	ϵ' / ϵ_0	1125	1122	1120	1110	1110	1090	1090	1090	1090
SrTiO ₃ 40%											

- a. 84.3% TiO₂, 11.1% MgCO₃ = 4.6% MgOSiO₂ (Lab. Ins. Res.). b. 84.6% TiO₂, 15.4% K₂SiO₃ (Lab. Ins. Res.). c. Calcium titanate (Titanium Alloy; fired at Lab. Ins. Res.). d. Strontium titanate (Titanium Alloy; fired at Lab. Ins. Res.). e. Barium titanate (Titanium Alloy; fired at Lab. Ins. Res.). f. 79% barium, 21% strontium titanate (Titanium Alloy; fired at Lab. Ins. Res.). g. Thin sheet (Glenco).

I. Solids, A. Inorganic (cont.)

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

2. Ceramics (cont.)

b. Titanias and titanates bodies (cont.)	$T^{\circ}\text{C}$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{740}$	$\frac{1x10^4}{738}$	$\frac{1x10^5}{735}$	$\frac{1x10^6}{732}$	$\frac{1x10^7}{730}$	$\frac{1x10^8}{730}$	$\frac{3x10^8}{730}$	$\frac{3x10^9}{730}$	$\frac{1x10^{10}}{730}$
Mix 76 BaTiO ₃ 50% ^a	25	ϵ'/ϵ_0	6.44	6.40	6.35	6.32	6.30	6.30	6.23	6.18	-----
SrTiO ₃ 50%			tan δ	10.7	6	7	21	28	-----	45	57
Mix 77 BaTiO ₃ 68.1% ^a	25	ϵ'/ϵ_0	892	890	890	890	890	890	-----	-----	5.51
SrTiO ₃ 28.1% ^a			tan δ	16	10	12	25	8	-----	-----	155
MgZrO ₃ 2.8% ^a			-----	-----	-----	-----	-----	-----	-----	-----	4.74

c. Porcelains

Zirconium porcelain Zr-4 ^b	25	ϵ'/ϵ_0	59	40	31	27	23	21	25	27	45
Porcelain, wet process ^c	25	ϵ'/ϵ_0	6.47	6.24	6.08	5.98	5.87	5.82	5.80	5.75	5.51
Porcelain, dry process ^d	25	ϵ'/ϵ_0	5.50	5.36	5.23	5.14	5.08	5.04	5.04	5.02	-----
Coors Al-200 ^d	25	ϵ'/ϵ_0	8.83	8.83	8.82	8.80	8.80	8.80	8.80	8.80	-----
Porcelain #4462 ^e	25	ϵ'/ϵ_0	8.99	8.95	8.95	8.95	8.95	8.95	8.95	8.95	8.80
Coors AB-2 ^d	25	ϵ'/ϵ_0	8.22	8.18	8.17	8.17	8.16	8.16	8.16	8.16	8.08
AlSiMag 491 ^f	25	ϵ'/ϵ_0	-----	-----	-----	-----	8.74	-----	-----	-----	8.60
d. Miscellaneous Ceramics											
Beryllium oxide ^g	25	ϵ'/ϵ_0	4.61	4.47	4.41	4.34	4.28	4.24	4.23	4.23	4.20
Porous Ceramic AF-497 ^h	25	ϵ'/ϵ_0	170	84	74	72	38	19	12.5	-----	5
			tan δ	-----	-----	-----	-----	-----	-----	-----	1.472
			Frequency = $1x10^9$	-----	-----	-----	-----	-----	-----	-----	17

a. Thin sheet (Glenco). b. Coors. c. Knox. d. Aluminum oxide (Coors). e. Aluminum oxide (Frenchtown Porcelain). f. Aluminum oxide (Amer. Lava). g. Norton. h. 63% diatomaceous-earth, 32% anthracite coal, 5.5% whiting (Stupakoff).

Frequency = $1x10^9$.

I. Solids, A. Inorganic, 2. Ceramics (cont.)

e. Ferrites

Frequency given in c/s; temperature = 25°C.

Crowloy 20^a

Freq.	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$
10^2	35400	2.41	----	----	40000	26.7	400	----	19.4	.59	----	----	29	.58	21	----
4×10^2	9900	3.94	----	----	----	----	----	----	14.7	.20	14.5	----	19.2	.30	17.5	----
10^3	5430	2.65	120	----	350000	3.35	400	----	13.0	.066	14.5	----	14.9	.15	15.6	----
10^4	1590	1.47	120	----	250000	.78	400	----	12.8	.024	14.5	----	12.9	.06	14.5	----
10^5	480	1.6	120	----	123000	.64	400	----	140	.28	12.6	.010	14	----	12.6	.024
10^6	----	----	----	----	----	----	----	147	1.53	----	13	<.1	----	16	----	16 <.1
3×10^6	----	----	----	108	.08	----	----	147	1.53	----	13	<.1	----	16	----	16 <.1
10^7	18	1.1	.84	.48	16400	1.4	.92	.24	12.5	.005	12.47 <.1	,02	12.4	.007	18.5	<.1
2×10^7	----	----	----	47	.92	----	----	147	1.53	----	12	<.2	----	20.7	----	20.7 <.1
3×10^7	----	----	----	35	1.16	----	----	147	1.53	----	12.8	,46	.05	,03	----	23 <.1
6.5×10^7	----	----	----	24.6	1.58	----	----	147	1.53	----	51	.25	----	----	24 <.1	----
8×10^7	----	----	----	17.9	2.15	----	----	29	2.36	----	49.4	.46	----	----	30 .13	----
10^8	----	----	----	15.9	1.98	----	----	18	3.35	12.5	.0026	37	.74	12.4	.0037	26 <.1
1.2×10^8	----	----	----	24.6	1.43	----	----	21	2.58	----	34	.9	----	----	31 .32	----
1.4×10^8	----	----	----	24.6	1.43	----	----	21	2.58	----	28.5	1.15	----	----	17.6	1.61
3×10^8	----	----	----	24.6	1.43	----	----	21	2.58	----	17.9	1.5	----	----	3.25	4.46
9×10^8	12	.07	----	24.6	1.43	----	----	21	2.58	----	5.34	3.4	----	----	2.48	2.48
10^9	12	.07	24.6	1.43	24.6	1.43	24.6	1.43	19	10.6	12 <.012	1.74	1.9	12 <.01	1.34	2.48
3×10^9	12	.04	.28	7.2	42	----	----	12 <.012	1.74	1.9	12 <.01	1.34	2.48	----	2.48	2.48

a. H. L. Crowley.

*Two samples were measured; they differed as shown by the two sets of values at 10^7 and 3×10^7 . Lower μ'/μ_0 values were obtained on sample cut from 2" disk, higher values on 3/4" disk. ϵ'/ϵ_0 values did not differ.

I. Solids, A. Inorganic, 2. Ceramics (cont.)

e. Ferrites (cont.)

Frequency given in c/s; temperature = 25°C.

Ferramic A ^{a,b}				Ferramic B ^a				Ferramic C ^a				Ferramic D ^a				
Freq.	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$
10 ³	9.82	.112	19.6	---	20800	4.5	---	---	110000	2.4	240	---	35000	84	380	84
10 ⁴	9.30	.026	19.6	---	19700	4.8	94	---	32000	1.44	240	---	35000	8.1	380	8.1
10 ⁵	9.13	.0076	19.5	---	15500	.78	---	---	22000	1	---	---	---	---	---	---
10 ⁶	8.99	.0032	19.4	---	8600	.65	---	---	13500	1.32	242	.015	17600	.77	510	<.05
2x10 ⁶	---	---	20.0	---	---	---	108	.027	---	---	259	---	---	---	550	.18
3x10 ⁶	---	---	22	---	---	---	---	---	---	267	.068	11000	.80	565	.47	
4x10 ⁶	---	---	---	---	---	---	---	---	---	---	---	---	---	411	.55	
7x10 ⁶	---	---	23	---	---	---	---	---	---	---	---	---	---	112	2.76	
10 ⁷	8.87	.0016	24.6	.08	1060	2.9	107	.36	2850	2.0	195	.85	6600	.90	52	4.0
2x10 ⁷	---	---	25.4	.177	---	---	---	---	---	---	78	1.6	---	---	17.7	5.8
3x10 ⁷	---	---	---	---	---	---	62	.67	---	---	33.5	2.7	---	---	12.9	6.2
5x10 ⁷	8.5	<.1	12.5	1.00	---	---	---	---	---	---	---	---	---	485	2.9	
10 ⁸	---	---	7.2	1.29	---	---	---	---	64	.70	16.8	.61	106	3.1	1.09	18.4
3x10 ⁸	---	---	2.8	1.6	51	1.56	14.4	1.12	---	---	---	---	---	---	8	
5x10 ⁸	---	---	2.0	1.2	---	---	---	---	---	---	---	---	---	---	20	
10 ⁹	8.5	<.1	3.0	.67	---	---	---	---	---	---	---	---	---	---	256	
2x10 ⁹	---	---	1.0	2.0	---	---	---	---	---	---	---	---	---	---	256	
3x10 ⁹	---	---	.6	2.0	20	.68	.29	10	24.6	1.14	.18	22	35	3.3	.15	
10 ¹⁰	8.5	<.1	1.0	---	15	.52	.42	.37	18.7	.58	.51	1.26	30	1.35	1.9	
Ferramic G ^a				Ferramic H ^a				Ferramic I ^a				Ferramic J ^a				
10 ³	---	450	---	670000	7.2	720	---	12000	2.9	890	---	---	---	---	256	
10 ⁴	23.5	.60	400	---	152500	4.5	720	---	7800	.81	890	---	17.5	1.95	256	
10 ⁵	15.5	.216	360	---	22400	4.2	720	---	930	3.1	890	<.1	13.8	.37	256	
10 ⁶	13.6	.069	340	.05	1600	8.2	690	.18	90	4.7	1050	.29	12.6	.062	256	
10 ⁷	13.0	.026	245	.66	---	---	300	1.33	26	2.1	215	1.6	12.4	.015	196	
3x10 ⁸	---	---	---	---	---	---	---	---	13.6	.114	10.7	1.03	---	---	66	
3x10 ⁹	---	---	---	---	---	---	---	---	12	.012	.90	.04	---	---	---	

a. Gen. Ceramics and Steatite. b. Data partly from Rado, Wright and Emerson, Phys. Rev. 80, 273 (1950).

I. Solids, A. Inorganic (cont.)

Values for tan 6 are multiplied by 10^4 ; frequency given in c/s.

3. Glasses	$\frac{1}{T}^{\circ}\text{C}$	$\frac{1 \times 10^2}{\epsilon/\epsilon_0}$	$\frac{1 \times 10^3}{\epsilon/\epsilon_0}$	$\frac{1 \times 10^4}{\epsilon/\epsilon_0}$	$\frac{1 \times 10^5}{\epsilon/\epsilon_0}$	$\frac{1 \times 10^6}{\epsilon/\epsilon_0}$	$\frac{1 \times 10^7}{\epsilon/\epsilon_0}$	$\frac{1 \times 10^8}{\epsilon/\epsilon_0}$	$\frac{3 \times 10^8}{\epsilon/\epsilon_0}$	$\frac{3 \times 10^9}{\epsilon/\epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon/\epsilon_0}$	$\frac{2 \cdot 5 \times 10^{10}}{\epsilon/\epsilon_0}$
Phosphate Glass #2043x ^a	25	ϵ'/ϵ_0	5.25	5.25	5.25	5.25	5.25	5.24	5.23	5.17	5.00	4.93
Phosphate Glass #2279x ^b	25	ϵ'/ϵ_0	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.9	4.9	4.9
Borosilicate Glass ^c	25	ϵ'/ϵ_0	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05
Corning 001c ⁱ	24	ϵ'/ϵ_0	6.68	6.63	6.57	6.50	6.43	6.39	6.33	6.1	5.96	5.87
Corning 0014 ^j	25	ϵ'/ϵ_0	6.78	6.77	6.76	6.75	6.73	6.72	6.70	6.69	6.64	6.61
Corning 0080f	23	ϵ'/ϵ_0	8.30	7.70	7.35	7.08	6.90	6.82	6.75	6.71	6.71	6.52
Corning 0090g	20	ϵ'/ϵ_0	9.15	9.15	9.14	9.12	9.10	9.02	9.02	8.67	8.45	8.25
Corning 0100h	25	ϵ'/ϵ_0	7.18	7.17	7.16	7.14	7.10	7.10	7.07	7.00	6.95	6.87
Corning 0120i	23	ϵ'/ϵ_0	6.75	6.70	6.66	6.65	6.65	6.65	6.65	6.64	6.60	6.51
Corning 1770j	25	ϵ'/ϵ_0	6.25	6.16	6.10	6.03	6.00	6.00	6.00	5.95	5.83	5.44
Corning 1990k	24	ϵ'/ϵ_0	8.40	8.38	8.35	8.32	8.30	8.25	8.20	7.99	7.94	7.84
Corning 1991n	24	ϵ'/ϵ_0	8.10	8.10	8.08	8.08	8.08	8.06	8.00	7.92	7.83	7.83
Corning 3320n	24	ϵ'/ϵ_0	5.00	4.93	4.88	4.82	4.79	4.78	4.77	4.74	4.72	4.7
Corning 7040o	25	ϵ'/ϵ_0	4.84	4.82	4.79	4.77	4.73	4.70	4.68	4.67	4.64	4.52
Corning 7050p	25	ϵ'/ϵ_0	4.88	4.84	4.82	4.80	4.78	4.76	4.75	4.74	4.71	4.64

a. Contains 2% iron oxide (Am. Optical). b. Aluminum-zinc phosphate. (ca. 70% P_2O_5) (Am. Optical). c. 73.2% SiO_2 , 24.8% B_2O_3 (Components and Systems Lab., Air Materiel Command). d. Soda-potash-lead silicate ca. 20% PbO . e. Lead-barium glass. f. Soda-lime-silicate. g. Soda-lime-silicate. h. Potash-soda-barium silicate. i. Soda-potash-lead-silicate. j. Lime-alumina-silicate. k. Iron-sealing glass. m. 45% SiO_2 , 14% K_2O , 6% Na_2O , 3% PbO , 5% CaO (iron-sealing glass). n. Soda-potash-borosilicate. o. Soda-potash-borosilicate. p. Soda-borosilicate (ca. 70% SiO_2).

I. Solids, A. Inorganic (cont.)

			Values for tan 8° are multiplied by 10 ⁴ ; frequency given in c/s.										
3. GLASSES (cont.)	T _C	ϵ'/ϵ_0	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
Corning 7052 ^a	23	ϵ'/ϵ_0	5.20	5.18	5.14	5.12	5.10	5.09	5.04	5.04	4.93	4.85	
		tan 8	68	49	34	26	24	28	34	30	58	81	114
Corning 7055	25	ϵ'/ϵ_0	5.45	5.41	5.38	5.33	5.31	5.30	5.27	5.25	5.25	5.08	
		tan 8	45	36	30	28	28	29	38	49	—	—	130
Corning 7060 ^b	25	ϵ'/ϵ_0	5.02	4.97	4.92	4.86	4.84	4.84	4.84	4.84	4.82	4.80	4.65
		tan 8	89	55	42	40	36	30	30	30	54	98	90
Corning 7070 ^c	23	ϵ'/ϵ_0	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.9
		tan 8	6	5	5	6	8	11	12	12	12	21	31
Corning 7230 ^d	100	ϵ'/ϵ_0	4.17	4.16	4.15	4.14	4.13	4.10	4.10	4.10	4.00	4.00	
		tan 8	50	22	13	10	9	11	—	—	19	21	
Corning 7570	25	ϵ'/ϵ_0	3.88	3.86	3.85	3.85	3.85	3.85	3.85	3.85	3.75	—	
		tan 8	33	23	16	13	11	12	—	—	22	—	
Corning 7720 ^e	25	ϵ'/ϵ_0	14.58	14.56	14.54	14.53	14.52	14.50	14.42	14.42	14.4	14.2	
		tan 8	11.5	13.5	15.9	16.5	19.0	23.5	33	44	—	98	
Corning 7740 ^f	24	ϵ'/ϵ_0	4.74	4.70	4.67	4.64	4.62	4.61	—	—	—	4.59	
		tan 8	78	42	29	22	20	23	—	—	—	43	
Corning 7750 ^f	25	ϵ'/ϵ_0	4.80	4.73	4.70	4.60	4.55	4.52	4.52	4.52	—	4.52	4.50
		tan 8	128	86	65	54	49	45	45	45	—	85	96
Corning 7900 ^g	20	ϵ'/ϵ_0	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	4.38	4.38	
		tan 8	45	33	24	20	18	19	—	—	43	54	
Corning 8460 ^h	100	ϵ'/ϵ_0	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.84	3.82	3.82
		tan 8	37	17	12	10	8.5	7.5	—	—	6	6.8	9.4
Corning 8830	25	ϵ'/ϵ_0	—	—	—	—	—	—	—	—	—	—	3.82
		tan 8	204	130	91	73	60	54	57	63	—	—	6.5

a. Soda-potash-lithia-borosilicate. b. Soda-borosilicate (Pyrex). c. Low alkali potash-lithia-borosilicate. d. Aluminum borosilicate.

e. Soda-lead borosilicate. f. Soda-borosilicate (ca. 80% SiO₂). g. 96% SiO₂. h. Barium borosilicate.

I. Solids, A. Inorganic (cont.)

Values for tan δ are multiplied by 10^{-4} ; frequency given in c/s.

	$T^{\circ}C$	ϵ'/ϵ_0	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
3. Glasses (cont.)													
Corning 8871 ^a	25	ϵ'/ϵ_0	8.45	8.45	8.45	8.45	8.45	8.43	-----	8.40	8.34	8.05	7.32
		$\tan \delta$	18	13	9	7	6	7	-----	14	26	49	70
Corning 9010	25	ϵ'/ϵ_0	6.51	6.49	6.48	6.45	6.44	6.43	6.42	6.40	-----	6.27	
		$\tan \delta$	50.5	36.2	26.7	22.7	21.5	22.6	30	41	-----	91	
Corning Lab. No. 189CS	25	ϵ'/ϵ_0	19.2	19.2	19.2	19.1	19.0	19.0	19.0	19.0	17.8	-----	
" E " Glass ^b	23	ϵ'/ϵ_0	6.43	6.40	6.39	6.37	6.32	6.25	6.22	-----	124	-----	
		$\tan \delta$	42	34	27	18	15	17	23	23	-----	60	
Fenglass ^c	23	ϵ'/ϵ_0	90.0	82.5	68.0	44.0	17.5	9.0	-----	-----	-----	5.49	
		$\tan \delta$	1500	1600	2380	3200	3180	1960	-----	-----	-----	455	
Fused Silica 915C ^d	25	ϵ'/ϵ_0	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78
Fused Silica 915C ^{d,e}	25	ϵ'/ϵ_0	6.6	2.6	1.1	0.4	0.1	0.1	0.3	0.5	-----	1.7	
		$\tan \delta$	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	
Fused quartz ^f	25	ϵ'/ϵ_0	0.08	0.13	< 0.05	-----	-----	-----	-----	-----	0.6	1	2.5
		$\tan \delta$	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	
Soda-Silica Glasses ^g													
9% Na ₂ O, 91% SiO ₂	25	ϵ'/ϵ_0	6.4	6.2	5.7	-----	5.4	-----	5.1	-----	5.05	4.9	
		$\tan \delta$	2500	820	400	-----	130	-----	100	-----	130	160	
12% Na ₂ O, 88% SiO ₂	25	ϵ'/ϵ_0	8.2	6.7	6.1	-----	5.6	-----	5.2	-----	5.15	5.04	
		$\tan \delta$	1900	600	300	-----	150	-----	100	-----	155	170	
16% Na ₂ O, 84% SiO ₂	25	ϵ'/ϵ_0	9.4	7.4	6.6	6.2	5.9	5.7	5.5	-----	5.27		
		$\tan \delta$	3000	960	500	250	165	130	110	-----	180		
20% Na ₂ O, 80% SiO ₂	25	ϵ'/ϵ_0	10.8	8.3	7.3	6.8	6.6	6.3	5.9	-----	5.6	6.1	
		$\tan \delta$	4000	1500	670	360	220	180	140	-----	200	280	
25% Na ₂ O, 75% SiO ₂	25	ϵ'/ϵ_0	13	9.7	8.4	-----	7.6	-----	6.7	-----	6.3		
		$\tan \delta$	6700	2400	1000	-----	310	-----	170	-----	220		
30% Na ₂ O, 70% SiO ₂	25	ϵ'/ϵ_0	18	12	10.4	-----	8.5	-----	7.5	-----	7.2	7.0	
		$\tan \delta$	11000	3900	1300	-----	400	-----	190	-----	240	350	

a. Alkaline lead silicate.

b. Owens-Corning.

c. Soda-lime (Pittsburgh-Corning).

d. SiO₂ (General Electric).

e. Sample B-135.

f. SiO₂ (General Electric).

g. Composition in mole % of oxides as mixed (Lab. Ins. Res.).

I. Solids, A. Inorganic (Cont.)

3. Glasses (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	$T^{\circ}\text{C}$	$1x10^2$	$1x10^3$	$1x10^4$	$1x10^5$	$1x10^6$	$1x10^7$	$1x10^8$	$3x10^8$	$3x10^9$	$1x10^{10}$
<u>Alkali-silica glasses^a</u>											
12.8% Li ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	9.94	6.54	5.45	5.1	4.95	4.92	---	4.9	---
		tan δ	9700	3600	1000	310	174	124	---	79	---
12.8% Na ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	8.09	6.61	6.00	5.8	5.66	5.57	---	5.4	---
		tan δ	3050	1370	450	240	159	126	---	118	---
12.8% K ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	7.53	6.49	6.25	6.17	6.09	6.02	---	5.8	---
		tan δ	502	360	200	121	90	80	---	99	---
12.8% K ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	7.10	6.63	6.30	6.12	6.10	6.08	---	5.95	---
Quenched		tan δ	730	470	270	160	119	103	---	106	---
12.8% Rb ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	5.39	5.32	5.23	5.22	5.21	5.20	---	5.15	---
		tan δ	98	89	58	46	41	38	---	59	---
6.4% Li ₂ O, 6.4% Na ₂ O,	25	ϵ'/ϵ_0	5.15	5.08	5.05	5.05	5.04	5.03	---	5.00	---
87.2% SiO ₂		tan δ	145	87	47	28	19	17	---	26	---
6.4% Li ₂ O, 6.4% K ₂ O,	25	ϵ'/ϵ_0	5.15	5.09	5.05	5.05	5.04	5.02	---	4.98	---
87.2% SiO ₂ Quenched		tan δ	150	87	47	27	19	21	---	31	---
3.3% Li ₂ O, 6.6% K ₂ O,	25	ϵ'/ϵ_0	5.23	5.19	5.17	5.15	5.14	5.10	---	5.07	---
71% SiO ₂		tan δ	53	47	37	28	24	24	---	40	---
3.3% Li ₂ O, 6.6% K ₂ O,	25	ϵ'/ϵ_0	5.38	5.35	5.28	5.26	5.23	5.20	---	5.15	---
91% SiO ₂ Quenched		tan δ	102	74	44	30	30	33	---	49	---
6.4% Na ₂ O, 6.4% K ₂ O,	25	ϵ'/ϵ_0	5.68	5.62	5.58	5.56	5.54	5.51	---	5.51	---
87.2% SiO ₂		tan δ	102	75	42	31	25	23	---	40	---
6.4% Na ₂ O, 6.4% K ₂ O,	25	ϵ'/ϵ_0	5.70	5.62	5.58	5.56	5.55	5.54	---	5.53	---
87.2% SiO ₂ Quenched		tan δ	129	89	47	36	33	34	---	44	---

a. Composition in mole % of oxides as mixed (Lab. Ins. Res.)

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I. Solids A. Inorganic (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

4. Mica and Glass	$T^\circ C$	ϵ'/ϵ_0	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	1×10^9	1×10^{10}	2.5×10^{10}	
Mycalox 2821 ^a (discontinued)	25	ϵ'/ϵ_0	7.50	7.50	7.50	7.50	7.45	7.45	----	----	7.09	27	
	tan δ	60	28	17	13	10	9	9	----	----	----	33	
Mycalox 400 ^b	25	ϵ'/ϵ_0	7.47	7.45	7.42	7.40	7.39	7.38	----	----	7.12	33	
	tan δ	29	19	16	14	13	13	13	----	----	7.32	57	
Mycalox K10 ^c	80	ϵ'/ϵ_0	7.64	7.59	7.54	7.52	7.50	7.47	----	----	11.3*	11.3*	
	tan δ	150	85	50	25	16	14	14	----	----	40	40	
Mykroy Grade 8 ^d	24	ϵ'/ϵ_0	9.5	9.3	9.2	9.1	9.0	9.0	----	11.3*	11.3*	57	
	tan δ	170	125	76	42	26	21	21	----	6.68**	6.96**	6.66	
Mykroy Grade 38 ^d	25	ϵ'/ϵ_0	6.87	6.81	6.76	6.74	6.73	6.73	6.72	----	38	48	81
	tan δ	95	66	43	31	26	24	25	----	7.68**	8.35**	7.68**	
Ruby mica ^e	25	ϵ'/ϵ_0	7.71	7.69	7.64	7.61	7.61	7.61	----	----	35	40	
	tan δ	43	33	27	24	21	14	14	----	----	----	----	
<u>5. Miscellaneous Inorganics</u>													
Canadian mica (field I sheet) (field II sheet)	26	ϵ'/ϵ_0	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	
	tan δ	25	6	3.5	3	3	3	3	2	2	2	3	
Marble S-3030 ^f (after drying over $P_{25}O_5$) (after baking)	25	ϵ'/ϵ_0	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	
	tan δ	2000	1100	630	390	360	370	370	290	250	250	120	
Selenium, amorphous ^g (Measured at 50% R.H.)	25	ϵ'/ϵ_0	9.45	9.42	9.29	9.25	9.07	8.98	8.85	8.85	8.85	8.53	
	tan δ	180	130	81	75	110	120	120	120	120	120	110	
Quinterra ^h (Measured at 50% R.H.)	25	ϵ'/ϵ_0	---	---	---	---	---	9.35	8.95	8.95	8.95	8.6	
	tan δ	---	---	---	---	---	---	500	250	250	250	250	
Quinorgo #3000 ⁱ (Measured at 50% R.H.)	25	ϵ'/ϵ_0	5.75	4.80	4.1	< 3	< 3	< 3	< 2	< 2	1.8	6.7	
	tan δ	210	2310	2150	1350	870	870	870	870	870	870	870	

a. Mica, glass (Gen. Elec.). b. Mica, glass (Mycalox). c. Mica, glass, TiO_2 (Mycalox). d. Mica, glass (Electronic Mech.).

e. Muscovite. f. Class A (Tenn. Marble). g. Amer. Smelt. and Refining. h. Asbestos fiber, chrysotile, Type I (Johns-Manville).

i. 85% chrysotile asbestos, 15% organic material (Johns-Manville).

*Not corrected for variations of density. **Samples nonhomogeneous.

I. Solids A. Inorganic (cont.)

5. Misc. Inorganics
(cont.)

	$T^{\circ}C$	Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.						
		$1x10^{-2}$	$1x10^{-3}$	$1x10^{-4}$	$1x10^{-5}$	$1x10^{-6}$	$1x10^{-7}$	$1x10^{-8}$
Sandy soil, dry	ϵ'/ϵ_0	3.42	2.91	2.75	2.55	2.55	2.55	2.55
	$\tan \delta$	.196	.08	.034	.020	.017	.016	.0100
2-18% moisture	ϵ'/ϵ_0	3.23	2.72	2.50	2.50	2.50	2.50	.0062
	$\tan \delta$	.64	.13	.056	.030	.025	.025	.025
3.88% moisture	ϵ'/ϵ_0	---	---	---	5.0	4.70	4.50	4.50
	$\tan \delta$	---	---	1500	---	1.75	.3	.03
16.8% moisture	ϵ'/ϵ_0	---	---	---	---	20	20	.046
	$\tan \delta$	---	3425	367	4	.35	---	.03
Loamy soil, dry	ϵ'/ϵ_0	3.06	2.83	2.69	2.60	2.53	2.48	2.47
	$\tan \delta$	.07	.05	.035	.03	.018	.014	.0065
2.2% moisture	ϵ'/ϵ_0	---	---	18	---	6.9	4	3.5
	$\tan \delta$	---	2.1	1.6	---	.65	.45	.06
13.77% moisture	ϵ'/ϵ_0	---	---	---	---	14.5	---	20
	$\tan \delta$	---	8490	970	---	1.3	---	.16
Clay soil, dry	ϵ'/ϵ_0	4.73	3.94	3.27	2.79	2.57	2.44	2.38
	$\tan \delta$	.12	.12	.12	.10	.065	.04	.020
20.09% moisture	ϵ'/ϵ_0	---	---	---	---	21.6	---	20
	$\tan \delta$	---	7800	1000	---	1.7	---	.52
Magnetite soil, dry	μ'/μ_0	---	---	---	1.09	1.09	---	1.09
	$\tan \delta_m$	---	---	---	---	---	---	1.005
4.8% moisture	ϵ'/ϵ_0	3.95	3.75	3.62	3.52	3.50	3.60	.025
	$\tan \delta_d$	.041	.029	.022	.017	.015	.012	.018
11.2% moisture	ϵ'/ϵ_0	---	---	---	12	10	---	9.0
	$\tan \delta_d$	---	---	$\rho = 2x10^5$ ohm cm	9	1.0	---	.22
Amplifilm^a	ϵ'/ϵ_0	4.34	4.32	4.30	4.30	4.30	4.29	.32
	$\tan \delta$	.00314	.0022	.0019	.0017	.0017	.0018	.2

I. Solids, B. Organic, with or without inorganic components - Values for tan δ are multiplied by 10⁴; frequency given in c/s.

	T°C	<u>1x10²</u>	<u>1x10³</u>	<u>1x10⁴</u>	<u>1x10⁵</u>	<u>1x10⁶</u>	<u>1x10⁷</u>	<u>1x10⁸</u>	<u>3x10⁹</u>	<u>1x10¹⁰</u>	<u>2.5x10¹⁰</u>
1. Crystals											
α-Trinitrotoluene ^a	26	ϵ'/ϵ_0	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64
		tan δ	36	20	11	6	4.5	4			
α-Trinitrotoluene at ca. 20% humidity ^b	25	ϵ'/ϵ_0	3.80	3.09	2.93	2.90	2.89	2.89	2.89	2.86	2.82
		tan δ	2600	900	200	40	20	17	28	39	14
Santicizer 9 ^c	25	ϵ'/ϵ_0	4.19	3.76	3.56	3.51	3.47	3.43	3.35	-----	3.21
		tan δ	1140	560	350	185	120	110	71	-----	28
Naphthalene ^d	25	ϵ'/ϵ_0	-----	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.8
		tan δ	-----	19	9	5	3	2	2	2	2.1
Orthoterphenyl ^e	25	ϵ'/ϵ_0	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.74
		tan δ	3.7	4.7	6.0	6.3	6	5	5	5	2.7
Metaterphenyl ^e	25	ϵ'/ϵ_0	-----	2.86	2.86	-----	2.86	2.86	2.86	2.86	2.83
		tan δ	-----	4.5	4.5	-----	9.5	10.1	5	5	0.7
Paraterphenyl ^e	25	ϵ'/ϵ_0	-----	(2.95-3.20 depending on degree of crystallization)	-----	-----	-----	-----	-----	-----	2.95
		tan δ	-----	2	1	<2	<2	<2	<2	<2	2.1
Aroclor 1268 ^f	25	ϵ'/ϵ_0	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64
		tan δ	14	3.5	2	<3	<3	<6	<6	<6	<6
2. Simple Noncrystals											
Aroclor 5460 ^g	25	ϵ'/ϵ_0	2.43	2.43	2.42	2.42	2.41	2.41	2.41	2.41	2.41
		tan δ	<3	4	16	20	18	13	8		
Aroclor 4465 ^h	25	ϵ'/ϵ_0	2.81	2.80	2.79	2.79	2.79	2.79	2.79	2.79	2.79
		tan δ	45	17	6.6	4	2.4	1.5	1.0	1.0	1.0

3. Plastics

a. Phenol-formaldehyde

Bakelite BM-120 ¹ (preformed and preheated)	25	ϵ'/ϵ_0	4.87	4.74	4.62	4.50	4.36	4.16	3.95	-----	3.70	3.68
		tan δ	300	220	200	210	280	350	380	-----	438	410

a. Chem. Lab. M.I.T. b. War Dept., Picatinny Arsenal. c. o- and p-toluene sulfonamides (Monsanto). d. Eastman Kodak: recryst. and resubl. Lab. Ins. Res. e. Monsanto, recryst. Lab. Ins. Res. f. Nonachlorobiphenyl (Monsanto). g. Nonachloroterphenyls (Monsanto).

h. Chlorinated mixture of biphenyl and terphenyl (Monsanto). i. 46% wood flour, 8% misc. (Bakelite).

I. Solids, B. Organic (cont.)

3. Plastics (cont.)		Values for tan δ are multiplied by 10^4 ; frequency given in c/s.										
a. Phenol-formaldehyde		$\frac{T^{\circ}C}{(cont.)}$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$	$\frac{2.5x10^{10}}{\epsilon'/\epsilon_0}$
Bakelite BM-120 ^a (not preformed or preheated)	27	ϵ'/ϵ_0	5.50	5.15	4.90	4.65	4.45	4.30	---	3.70	3.55	2.52x10 ¹⁰
		$\tan \delta$	740	460	345	320	350	415	---	400	500	
Bakelite BM-250 ^b (preformed and preheated)	57	ϵ'/ϵ_0	7.80	6.35	5.70	5.30	4.90	4.65	4.5	---	4.15	
		$\tan \delta$	2950	1150	530	380	430	470	480	---	530	
Bakelite BT-48-306 ^c	88	ϵ'/ϵ_0	18.2	8.5	6.5	5.7	5.2	5.0	4.7	---	4.40	
		$\tan \delta$	7600	3700	1400	600	400	420	470	---	700	
Bakelite BM-16981 ^d (not preformed or preheated)	25	ϵ'/ϵ_0	37	22	12	7.2	5.3	5.0	---	---	---	5.0
		$\tan \delta$	3000	3700	3900	2900	1250	220	---	---	---	320
Bakelite BM-16981 ^d	24	ϵ'/ϵ_0	8.2	7.15	6.5	5.9	5.4	4.9	4.4	---	3.64	3.52
		$\tan \delta$	1350	820	630	560	600	730	770	---	51.9	366
Bakelite BM-16981 ^d	25	ϵ'/ϵ_0	7.6	6.1	5.4	5.1	4.9	4.8	4.7	---	4.6	4.5
		$\tan \delta$	2300	1000	500	300	200	130	100	---	.00	120
Bakelite BM-16981 ^d (preformed and preheated)	25	ϵ'/ϵ_0	4.82	4.73	4.66	4.62	4.60	4.59	4.58	---	4.57	4.57
		$\tan \delta$	140	120	100	70	52	50	60	---	90	85
Bakelite BM-16981 ^d (powder preheated)	25	ϵ'/ϵ_0	5.05	4.87	4.80	4.79	4.72	4.67	4.62	---	---	4.52
Laminated Fiberglas	24	ϵ'/ϵ_0	14.2	9.8	7.2	5.9	5.3	5.0	4.8	4.54	4.10	4.37
EK-174 ^e		$\tan \delta$	2500	2600	1600	880	460	340	260	240	290	360
Catalin 200 base, white ^f	22*	ϵ'/ϵ_0	8.6	8.2	7.9	7.5	7.0	6.5	---	---	4.89	
		$\tan \delta$	400	290	330	400	500	650	---	---	1080	
	85*	ϵ'/ϵ_0	53.5	34	24	17	12	9.5	---	---	5.81	
	25**	ϵ'/ϵ_0	6.9	6.7	6.6	6.5	6.3	5.8	---	5.1	4.61	
		$\tan \delta$	130	170	260	330	380	480	---	878	926	

a. 46% wood flour, 8% misc. (Bakelite). b. 66% asbestos fiber (Bakelite). c. 100% (Bakelite). d. Mica-filled (Bakelite).

e. 31.6% Bakelite's BV-17085, 68.4% Fiberglas (Owens Corning). f. Catalin.

* Measured December, 1943. **Same material measured after two years at room temperature and humidity.

I. Solids, B. Organic 3. Plastics (cont.)

a. Phenol-formaldehyde		$T^{\circ}\text{C}$	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^9}{\epsilon' / \epsilon_0}$	1×10^{10}	2.5×10^{10}
(cont.)		22*	ϵ' / ϵ_0	9.7	9.4	8.8	8.1	7.3	6.3	----	4.90	4.72
Catalin 500 base, yellow ^a		tan δ	280	320	400	550	760	1200	----	996	870	
		25**	ϵ' / ϵ_0	4.92	4.86	4.78	4.69	4.57	4.40	4.2	4.02	3.7
		tan δ	66	100	150	230	330	460	580	620	520	360
Catalin 500 base, standard ^a		25	ϵ' / ϵ_0	20.0	15.2	12.6	10.8	9.6	8.4	----	5.79	4.77
		tan δ	2800	1500	1000	860	940	1200	----	1540	1250	1300
Catalin 700 base (Crystal) ^a		25*	ϵ' / ϵ_0	94	44	16	11	8	6	----	----	4.74
		tan δ	16500	8000	4100	2300	1600	1400	----	----	1530	
		80*	ϵ' / ϵ_0	----	----	51	18.5	10.0	7.4	----	----	4.77
		tan δ	----	----	13200	6600	3700	2400	----	----	1640	
		25**	ϵ' / ϵ_0	58	24	14	9.6	8.0	6.6	5.0	4.1	3.7
		tan δ	14000	6400	3100	1900	1500	1400	950	740	500	
Durez 1601, natural ^b		26	ϵ' / ϵ_0	5.09	4.94	4.80	4.68	4.60	4.55	4.51	----	4.48
		tan δ	270	210	132	100	80	70	64	----	62	62
Durite 500 ^c		24	ϵ' / ϵ_0	5.10	5.03	4.95	4.86	4.78	4.72	4.72	4.71	4.70
		tan δ	130	104	86	78	82	102	115	----	126	128
Formica IX ^d		26	ϵ' / ϵ_0	5.23	5.15	4.96	4.78	4.60	4.32	4.04	----	3.57*** 3.55+
(field ⊥ to laminate)		tan δ	230	165	170	230	340	490	570	----	600***	700+
Formica IX ^e		26	ϵ' / ϵ_0	6.50	5.70	5.30	5.00	4.75	4.35	3.95	----	3.35*** 3.25+
(field ⊥ to laminate)		tan δ	1350	600	430	400	410	480	500	----	400***	460+
Grade YW-25 ^f		25	ϵ' / ϵ_0	3.73	3.65	3.61	3.61	3.59	3.47	----	3.24++	3.20
(field II to laminate)		tan δ	121	132	200	207	187	187	----	183++	178	173
		25	ϵ' / ϵ_0	3.87	3.77	3.68	3.61	3.55	3.47	----		
(field ⊥ to laminate)		tan δ	166	150	182	204	182	191	----			
Panelyte Grade 776 ^g		25	ϵ' / ϵ_0	4.25	4.18	4.10	3.95	3.87	3.73	3.52	3.40	3.12
		tan δ	190	150	160	200	280	370	400	390	370	340
											3.05	310

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^a Catalin. ^b 67% mica (Durez). ^c 65% mica, 4% lubricants (Durite). ^d a. 50% paper laminate (Formica). ^e 40% cotton fabric (Formica). ^f 50% Nylon fabric (Formica). ^g Paper base (St. Regis).

^{**}Measured December, 1943. ^{**}Same material measured after two years at room temperature and humidity. ^{***}Rod stock in coaxial line. [†]Rod stock in H₁₁ (TE₁₁) mode of circular guide. ⁺Freq. = 1×10^9 .

I. Solids, B. Organic (Cont.).

3. Plastics (cont.)		Values for tan δ are multiplied by 10^4 ; frequency given in c/s.											
b. Phenol-formaldehyde (Cont.)		$\frac{T^{\circ}C}{T^{\circ}}$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$	$\frac{2.5x10^{10}}{\epsilon'/\epsilon_0}$
Micarta #254 ^a (field ⊥ to laminate)	-13	ϵ'/ϵ_0	4.9	4.7	4.5	4.4	4.2	4.0	3.4	----	3.34	3.13	
		tan δ	250	220	240	280	370	390	370	----	286	215	
	25	ϵ'/ϵ_0	5.30	4.95	4.81	4.66	4.51	4.20	3.85	3.78	3.43	3.25	3.21
		tan δ	760	330	260	270	360	470	550	470	505	410	380
	82	ϵ'/ϵ_0	9.2	6.3	5.5	5.3	5.1	4.9	----	----	4.02	3.21	
		tan δ	4100	1820	690	360	300	400	----	----	984	773	
Micarta #496 ^b (field ⊥ to laminate)	25	ϵ'/ϵ_0	8.6	7.0	6.3	5.6	5.2	4.8	4.38	----	----	----	
		tan δ	2200	1100	630	500	480	630	710	----	510*	550*	570*
Micarta #496 ^b (field || to laminate)	25	ϵ'/ϵ_0	----	----	----	----	----	----	----	3.95*	3.78*	3.62*	
Phenolic paper laminate JE-1410 ^c	25	ϵ'/ϵ_0	4.21	4.17	4.12	4.06	3.94	3.81	3.62	----	----	----	
		tan δ	146	100	115	162	222	295	339	----	----	----	
Resinox 10231 ^d	25	ϵ'/ϵ_0	11.4	9.3	7.6	6.2	5.4	5.0	4.8	4.8**	4.7	4.6	
		tan δ	1390	1410	1440	1180	700	400	290	310**	330	340	
Resinox 10900 ^e	25	ϵ'/ϵ_0	4.80	4.64	4.45	4.37	4.24	4.23	4.08	4.05**	4.03	4.02	
Taylor Grade CCC ^f (field || laminate)	25	ϵ'/ϵ_0	7.25	6.08	4.67	4.14	4.00	3.9	3.9	3.9**	100	96	
(field ⊥ laminate)	25	ϵ'/ϵ_0	3.95	3.91	3.85	3.82	3.75	3.68	3.64	200**	250	290	
Dilecto (Mecoboard) ^g	25	ϵ'/ϵ_0	4.20	3.98	3.79	3.62	3.46	3.37	3.23	3.18	3.11	3.08	
		tan δ	400	344	318	304	263	223	216	215	220	229	
	90	ϵ'/ϵ_0	11.90	8.40	6.23	5.60	5.32	4.34	----	3.35	----	3.30	
		tan δ	2310	1640	1020	584	570	970	----	660	----	470	

a. Cresylic acid-formaldehyde, 50% α -cellulose (Westinghouse). b. Cresylic acid-formaldehyde, 50% cotton drilling. (Westinghouse).

c. 35% paper (Catalin). d. 53% filler (Monsanto).

e. 35% mica, 18% filler (Monsanto). f. 40% random glass mat (Taylor).

g. 45% cresol-phenol formaldehyde, 15% tung oil, 15% nylon (Continental Diamond).

*Samples turned from sheet stock. **freq = 1×10^9 .

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I. Solids, 3. Organic (Cont.)

3. Plastics (cont.)

	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$
a. Phenol-formaldehyde (Cont.)	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$
Dilecto (hot punching) XX-P-26 ^a	25	ϵ' / ϵ_0	14.7	8.61	6.68	5.76	5.05	4.60	4.10
		$\text{tan } \delta$	6420	2970	1380	840	720	690	680
(Field II sheet)	90	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	---	---	---	---	---	4.36	---
		$\text{tan } \delta$	---	---	---	---	---	950	---
	120	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	---	---	---	---	---	4.76	---
		$\text{tan } \delta$	---	---	---	---	---	990	---
(Field I sheet)	25	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	4.29	4.21	4.14	4.01	3.89	3.73	3.56
		$\text{tan } \delta$	137	119	137	180	250	340	390
	90	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	5.74	5.09	4.77	4.57	4.32	4.16	440
		$\text{tan } \delta$	1990	620	360	284	273	308	
	120	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	7.42	5.38	4.80	4.52	4.34	4.21	
		$\text{tan } \delta$	6700	1910	630	380	290	322	
Micarta #299 ^b (field ⊥ to laminate)	24	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	5.36	5.29	5.20	5.10	5.01	4.92	4.80
		$\text{tan } \delta$	270	130	115	122	138	150	170
Micarta #299 ^b (field || to laminate)	24	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	---	---	---	---	---	4.54*	4.34*
Durite #221X ^c	24	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	6.70	5.70	5.30	4.90	4.55	4.30	4.15
		$\text{tan } \delta$	2000	820	520	470	430	400	390
	84	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	13.8	7.0	5.8	5.2	4.9	4.5	4.3
		$\text{tan } \delta$	9000	3300	1200	550	460	470	420
Corfoam 114 ^d	25	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	---	---	---	---	---	---	1.36
		$\text{tan } \delta$	---	---	---	---	---	---	750
Expanded plastic board CP-TB ^e	25	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	---	---	---	---	---	---	1.21
Expanded phenolic board (dark) ^e	25	$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	---	---	---	---	---	---	80
		$\text{tan } \delta$	---	---	---	---	---	---	1.185
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a. 45% cresol-phenol formaldehyde, 15% tung oil, 40% a paper (Conti. Diamond). b. Cresylic acid-formaldehyde, 60-65% glass fabric (Westinghouse). c. Phenol-furfuraldehyde (Durite). d. Expanded Phenolic, den. 0.292 (Rezolin). e. Sponge Rubber Prod. *Stacked sheets in coaxial line. **Stacked sheets in H₁₁ (TE₁₁) mode of circular guide.

I. Solids, B. Organic (Cont.)

		Values for tan S are multiplied by 10^4 ; frequency given in c/s.									
		T_C	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^8}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$
b. Phenol-aniline-formaldehyde		25	ϵ'/ϵ_0	4.85	4.80	4.74	4.72	4.67	4.66	4.65	4.55
Bakelite BM-262 ^a (preformed and preheated)		tan S	98	82	75	60	55	55	57	57	4.5
Bakelite BM-262 ^a (not preformed or preheated)		26	ϵ'/ϵ_0	4.9	4.8	4.75	4.7	4.65	4.65	4.58	4.45
		tan S	235	165	113	83	70	65	80	80	89
		84	ϵ'/ϵ_0	5.8	5.4	5.1	5.0	4.9	4.8	4.7	4.58
		tan S	680	440	280	210	160	135	120	120	104
Bakelite BM-1895 ^b (preformed and preheated)		25	ϵ'/ϵ_0	4.80	4.72	4.70	4.67	4.64	4.61	4.58	4.43
Bakelite BM-1895 ^b (not preformed or preheated)		28	ϵ'/ϵ_0	5.0	4.9	4.75	4.65	4.55	4.55	4.53	4.35
		tan S	138	122	106	90	72	57	60	60	130
		84	ϵ'/ϵ_0	5.8	5.3	5.0	4.8	4.65	4.6	4.6	4.44
		tan S	740	470	310	225	175	140	125	125	100
Durez 11863 ^c (preformed and preheated)		-12	ϵ'/ϵ_0	4.68	4.59	4.52	4.48	4.42	4.39	4.39	4.31
		tan S	97	84	66	52	43	38	38	38	20
		25	ϵ'/ϵ_0	4.76	4.70	4.64	4.60	4.55	4.50	4.48	4.32
		tan S	108	100	82	62	52	48	52	52	47
		30	ϵ'/ϵ_0	5.26	5.03	4.87	4.74	4.63	4.55	4.48	4.42
		tan S	504	290	195	145	125	113	113	113	106
Durez 11863 ^c (not preformed or preheated)		26	ϵ'/ϵ_0	5.44	5.22	5.04	4.90	4.78	4.69	4.69	4.52
Formica Grade MF-66 Fiberglas ^d		25	ϵ'/ϵ_0	4.53	4.50	4.43	4.38	4.31	4.24	4.11	3.90
		tan S	106	95	107	102	95	109	100	105	3.85
		79	ϵ'/ϵ_0	4.94	4.75	4.66	4.59	4.51	4.44	4.35	4.20
		tan S	350	192	135	110	105	110	130	130	300
Resinox 7934 ^e (preformed and preheated)		25	ϵ'/ϵ_0	4.62	4.46	4.34	4.28	4.20	4.13	4.10	4.04
		tan S	220	210	178	130	99	88	85	84	83

a. 62% mica (Bakelite). b. 59.5% mica, 8.5% misc. (Bakelite). c. 43% mica, 5% misc.; discontinued, substitute 12810 (Durez). d. 40% glass mat (Formica). e. 60% mica (Monsantc).

I. Solids, B. Organic (Cont.)

3. Plastics (cont.)

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.									
					$\frac{1x10^3}{\epsilon/\epsilon_0}$	$\frac{1x10^4}{\epsilon/\epsilon_0}$	$\frac{1x10^5}{\epsilon/\epsilon_0}$	$\frac{1x10^6}{\epsilon/\epsilon_0}$	$\frac{1x10^7}{\epsilon/\epsilon_0}$
c. Aniline-formaldehyde	T_c				$\frac{1x10^2}{\epsilon/\epsilon_0}$	$\frac{1x10^3}{\epsilon/\epsilon_0}$	$\frac{1x10^4}{\epsilon/\epsilon_0}$	$\frac{1x10^5}{\epsilon/\epsilon_0}$	$\frac{1x10^6}{\epsilon/\epsilon_0}$
Cibanite E ^a	25	ϵ'/ϵ_0	3.58	3.57	3.56	3.48	3.41	3.41	3.41
	tan δ	29	41	69	85	79	49	39	---
Dilectene 100 ^b (1943 product)	22	ϵ'/ϵ_0	3.6	3.6	3.55	3.5	3.5	3.5	3.44
	tan δ	33	45	76	90	72	41	32	---
Dilectene 100 ^b (1944 product)	84	ϵ'/ϵ_0	3.6	3.6	3.6	3.6	3.55	3.5	3.44
	tan δ	36.5	34	37	50	90	83	61	47
d. Melamine-formaldehyde	25	ϵ'/ϵ_0	3.68	3.68	3.66	3.6	3.58	3.50	3.44
	tan δ	33	32	57	68	61	47	33	26
Formica Grade FF-41 ^c (sheet stock)	26	ϵ'/ϵ_0	6.15	6.00	5.95	5.85	5.75	5.65	5.5
	tan δ	400	119	86	93	115	165	200	---
Formica Grade FF-41 ^c (rod stock)	26	ϵ'/ϵ_0	---	---	3.7	3.7	3.65	3.6	---
	tan δ	---	---	---	50	48	80	111	---
Formica Grade FF-55 ^d (field ⊥ to laminate)	24	ϵ'/ϵ_0	6.55	6.35	6.20	6.05	6.00	5.90	5.80
	tan δ	400	142	85	85	108	155	220	250
Formica FF-55 ^d (field II to laminate)	24	ϵ'/ϵ_0	---	---	---	---	---	5.55*	5.31*
	tan δ	---	---	---	---	---	---	---	5.4***
GME Melamine ^e (field ⊥ to laminate)	25	ϵ'/ϵ_0	8.2	7.0	6.7	6.6	6.4	6.3	6.1
	tan δ	1900	690	190	100	110	180	230	230
GME Melamine ^e (field II to laminate)	25	ϵ'/ϵ_0	---	---	---	---	---	5.4	5.4
Melmac Resin 592 ^f	27	ϵ'/ϵ_0	6.70	6.25	5.85	5.50	5.20	4.90	4.70
	tan δ	590	470	410	375	347	326	360	360
									4.70
									4.75
									4.80
									4.90
									4.95
									4.95
Melmac Type 1077 ^g (Ivory WB 48)	28	ϵ'/ϵ_0	7.00	6.90	6.75	6.50	6.20	5.90	5.20
	tan δ	240	130	140	190	280	440	440	1000
a. 10% (Ciba). b. 100% (Continental-Diamond). c. 55% filler (Formica). d. Glass fiber mat (Formica). e. Glass Lamicoid #6038 (Mica Insulator). f. Mineral filler (Am. Cyanamid). g. 25% alpha pulp, Zn stearate (Am. Cyanamid).									
*Stacked sheets in coaxial line. ** Stacked sheets in H ₁₁ (TE ₁₁) mode of circular guide.									

I. Solids. B. Organic 3. Plastics (Cont.)

		Values for tan δ are multiplied by 10^4 ; frequency given in c/s.								
		<u>1×10^2</u>	<u>1×10^3</u>	<u>1×10^4</u>	<u>1×10^5</u>	<u>1×10^6</u>	<u>1×10^7</u>	<u>1×10^8</u>	<u>1×10^9</u>	<u>1×10^{10}</u>
d. Melamine-formaldehyde (cont.)	T°C									
Melmac Molding	25 ϵ'/ϵ_0	6.50	6.31	6.18	6.01	5.85	5.53	5.10	4.37*	4.20
Compound 1500 ^a	tan δ	303	173	162	221	320	415	500	523*	520
Melmac Molding	25 ϵ'/ϵ_0	8.43	6.95	6.37	6.04	5.77	5.36	4.90	4.40*	4.20
Compound 1502 ^b	tan δ	2020	960	460	350	410	510	560	620*	620
Polyglass M ^c	24 ϵ'/ϵ_0	5.58	5.53	5.49	5.40	5.32	5.22	----	4.86**	5.22**
	tan δ	140	71	64	69	93	160	----	339**	660**
	80 ϵ'/ϵ_0	8.4	6.5	5.9	5.8	5.8	5.8	----	5.68**	5.32**
	tan δ	4000	1400	280	95	65	110	----	498**	721**
Micarta #259 ^d	24 ϵ'/ϵ_0	6.18	6.07	5.97	5.90	5.81	5.72	5.55	----	4.80++
(field ⊥ to laminate)	tan δ	190	125	105	85	108	145	200	----	3224++
Micarta #259 ^d	24 ϵ'/ϵ_0	----	----	----	----	----	----	----	150***	260***
(field || to laminate)	tan δ	----	----	----	----	----	----	----	4.83***	4.75***
Panelyte 140 ^e	24 ϵ'/ϵ_0	6.15	6.05	6.00	5.93	5.82	5.70	5.55	5.12+	4.70++
(field ⊥ to laminate)	tan δ	135	93	120	155	155	170	215	260	360
Panelyte 140 ^e	25 ϵ'/ϵ_0	----	----	----	----	----	----	4.95	4.73	4.60
(field || to laminate)	tan δ	----	----	----	----	----	----	210	250	260
Plaskon Melamine ^f	24 ϵ'/ϵ_0	7.73	7.57	7.40	7.26	7.00	6.45	6.0	5.73	4.60
	tan δ	190	122	150	240	410	640	850	985	1100
	80 ϵ'/ϵ_0	9.86	8.7	8.4	8.4	7.9	7.5	7.0	5.5	5.04
	tan δ	1800	560	210	140	220	410	700	1250	1490
Resinene 803-A ^g (not preformed or preheated)	24 ϵ'/ϵ_0	7.05	6.90	6.75	6.50	6.20	5.70	5.20	5.04	4.23
Resinene 803-A ^g	25 ϵ'/ϵ_0	----	----	----	----	----	----	----	3.75	3.74
(powder preheated)	tan δ	----	----	----	----	----	----	----	320	300

a. 40% wood flour, 18% plasticizer (Am. Cyanamid). b. 60% melamine, formaldehyde and aniline polymer with wood flour filler (Am. Cyanamid). c. 56.5% Am. Cyanamid's Melmac 7278, 43.5% Owens-Corning's Glass "E" (Hood Rubber). d. 65-70% Fiberglas (Westinghouse). e. Fiberglas (St. Regis). f. α-cellulose (Libbey-Owens-Ford). g. 40% cellulose (Monsanto).

* Freq. = 1×10^9 . ** Sample nonhomogeneous; stacked layers. ***In coaxial lines. +In H₁₁(TE₁₁) mode circular guide. ++In H₀₁ (TE₀₁) mode rectangular guide.

I. Solids. B. Organic 3. Plastics (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	$\frac{1 \times 10^2}{T^{\circ}C}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{tan \delta}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{tan \delta}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{tan \delta}$	$\frac{3 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^9}{tan \delta}$	$\frac{1 \times 10^{10}}{T^{\circ}C}$	$\frac{1 \times 10^{10}}{tan \delta}$
e. Urea-formaldehyde											
Beetle Resin ^a	27	ϵ' / ϵ_0	6.5	6.2	6.05	5.9	5.65	5.4	5.1	4.47	4.37
	tan δ										
Plaskon Urea, natural ^b	24	ϵ' / ϵ_0	7.1	6.7	6.4	6.2	6.0	5.7	5.2	5.0	5.55
	tan δ										570
	80	ϵ' / ϵ_0	8.8	7.8	7.4	7.1	6.8	6.6	6.2	5.54	4.27
	tan δ										
Plaskon Urea, brown ^b	24	ϵ' / ϵ_0	6.65	6.35	6.15	6.00	5.75	5.42	5.0	4.82	4.60
	tan δ										4.55

f. Benzoguanamine-formaldehyde

	$\frac{1 \times 10^2}{T^{\circ}C}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{tan \delta}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{tan \delta}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{tan \delta}$	$\frac{3 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^9}{tan \delta}$	$\frac{1 \times 10^{10}}{T^{\circ}C}$	$\frac{1 \times 10^{10}}{tan \delta}$
Benzoguanamine Resin ^c	25	ϵ' / ϵ_0	4.72	4.58	4.50	4.40	4.26	4.15	3.96	3.62*	3.52
	tan δ										3.38
g. Polyamide Resins											
Nylon 66 ^d	25	ϵ' / ϵ_0	3.88	3.75	3.60	3.45	3.33	3.24	3.16	3.03	
	tan δ										
Nylon 610 ^d	25	ϵ' / ϵ_0	3.60	3.50	3.35	3.24	3.14	3.05	3.0	2.84	2.3
	tan δ										
	84	ϵ' / ϵ_0	13.5	11.2	9.0	6.3	4.4	3.7	3.4	2.94	105
	tan δ										
Nylon 610 ^d -90% humidity	25	ϵ' / ϵ_0	4.5	4.2	4.0	3.7	3.2	3.05	3.0	2.85	
	tan δ										
Nylon FM 1000 ^d	25	ϵ' / ϵ_0	3.84	3.76	3.64	3.49	3.36	3.24	3.17	3.06*	3.02
	tan δ										
Resin #90S ^e	25	ϵ' / ϵ_0	3.25	2.94	2.80	2.72	2.64	2.61	2.58	2.54	2.53
	tan δ										

h. Cellulose Derivatives

	$\frac{1 \times 10^2}{T^{\circ}C}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{tan \delta}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{tan \delta}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{tan \delta}$	$\frac{3 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^9}{tan \delta}$	$\frac{1 \times 10^{10}}{T^{\circ}C}$	$\frac{1 \times 10^{10}}{tan \delta}$
1) Acetates											
LL-1 ^f	25	ϵ' / ϵ_0	3.82	3.77	3.67	3.53	3.42	3.30	3.29	3.28	3.24
	tan δ										3.1
	85	ϵ' / ϵ_0	3.98	3.96	3.90	3.77	3.58	3.44	3.44	3.30	3.10
	tan δ										

a. Cellulose (Am. Cyanamid). b. α-cellulose (Libbey-Owens-Ford). c. 28% α paper (Am. Cyanamid). d. Hexamethylene-adipamide (Dupont).

e. Code RC-2072 (General Mills). f. 55.4% acetyl (Hercules).

* Freq. = 1×10^9 .

I. Solids, B. Organic, 3. Plastics (cont.)

Values for tan 6 are multiplied by 10^4 ; frequency given in c/s.

<u>h. Cellulose Derivatives (cont.)</u>	<u>T_C</u>	<u>$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$</u>	<u>$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$</u>	<u>$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$</u>	<u>$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$</u>	<u>$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$</u>	<u>$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$</u>	<u>$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$</u>	<u>$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$</u>	<u>$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$</u>	<u>$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$</u>
1) Acetates (cont.)											
Lumarith XFA-H4 ^a	25	ϵ' / ϵ_0	4.61	4.51	4.36	4.13	3.79	3.57	3.37	3.20*	3.13
Fibestos 2050TVA C-1686 ^b	26	ϵ' / ϵ_0	4.75	4.53	4.30	3.82	3.60	3.52	3.35	3.25	3.08
Tenite I 008A H ₂ ^c	26	ϵ' / ϵ_0	4.65	4.55	4.40	4.20	3.96	3.72	3.47	3.16	3.08
Tenite I 008A H ₄ ^c	26	ϵ' / ϵ_0	4.55	4.48	4.33	4.14	3.90	3.63	3.40	3.10	3.08
Tenite I 008A M ^c	26	ϵ' / ϵ_0	4.97	4.86	4.70	4.52	4.25	3.88	3.57	3.25	3.11
Tenite I 008A S ^c	26	ϵ' / ϵ_0	4.87	4.80	4.60	4.40	4.18	3.80	3.5	3.16	3.11
Tenite I 008A S ₄ ^c	26	ϵ' / ϵ_0	5.14	5.06	4.90	4.64	4.30	3.96	3.65	3.30	3.09
Tenite II 205A S ₄ ^c	26	ϵ' / ϵ_0	5.17	4.70	4.20	3.80	4.65	5.25	5.50	3.80	3.24
Tenite II 205A H ₄ ^d	26	ϵ' / ϵ_0	5.00	4.80	4.40	4.18	4.05	4.20	4.50	3.70	3.30
Tenite II 205A H ₂ ^d	26	ϵ' / ϵ_0	5.00	4.60	4.20	3.90	3.70	3.95	4.20	3.40	3.1
Tenite II 205A MH ₄ ^d	27	ϵ' / ϵ_0	3.54	3.48	3.42	3.37	3.30	3.18	3.05	2.80	2.80
Tenite II 205A MS ₂ ^d	27	ϵ' / ϵ_0	3.54	3.50	3.44	3.38	3.28	3.18	3.05	2.80	2.80
Tenite II 205A S ₄ ^d	27	ϵ' / ϵ_0	3.67	3.64	3.55	3.45	3.40	3.28	3.15	2.92	2.83
Tenite II 205A S ₄ ^d	27	ϵ' / ϵ_0	3.80	3.75	3.66	3.58	3.48	3.38	3.20	2.98	2.88
Tenite II 205A S ₄ ^d	27	ϵ' / ϵ_0	3.83	3.80	3.74	3.66	3.58	3.44	3.30	3.08	2.8

a. 20% plast. (Celanese). b. 26% plasticizer (Monsanto). c. 23-31% plasticizer, pigments, dyes (Tenn. Eastman). d. 5-15% plasticizer pigments, dyes (Tenn. Eastman).

* Freq. = 1×10^9 .

I. Solids, 3. Organic 3. Plastics (cont.)

h. Cellulose Derivatives (cont.)		Values for tan δ are multiplied by 10 ⁴ ; frequency given in c/s.									
	$\frac{f^0 C}{\epsilon' / \epsilon_0}$	$\frac{1x10^2}{\epsilon' / \epsilon_0}$	$\frac{1x10^3}{\epsilon' / \epsilon_0}$	$\frac{1x10^4}{\epsilon' / \epsilon_0}$	$\frac{1x10^5}{\epsilon' / \epsilon_0}$	$\frac{1x10^6}{\epsilon' / \epsilon_0}$	$\frac{1x10^7}{\epsilon' / \epsilon_0}$	$\frac{1x10^8}{\epsilon' / \epsilon_0}$	$\frac{1x10^9}{\epsilon' / \epsilon_0}$	$\frac{1x10^{10}}{\epsilon' / \epsilon_0}$	$\frac{1x10^{10}}{\epsilon' / \epsilon_0}$
2) Propionate	25	3.52	3.48	3.41	3.33	3.23	3.18	3.08	2.95	2.88	2.87
Forticel ^a			tan δ	60	101	157	188	175	164	192	247
3) Nitrate	27	ϵ' / ϵ_0	10.8	8.4	7.5	7.0	6.6	6.1	5.2	----	3.32
Pyralin ^b		tan δ	6400	1000	450	400	640	930	1030	----	1310
	78	ϵ' / ϵ_0	----	7.5	6.7	6.3	6.2	6.1	5.2	----	4.0
		tan δ	----	7000	1500	600	640	930	1030	----	1620
4) Methyl Cellulose	22	ϵ' / ϵ_0	7.6	6.8	6.4	6.1	5.7	4.9	4.3	----	3.35
Methocel ^c		tan δ	1280	570	330	400	650	1020	1000	----	550
5) Ethyl Cellulose	25	ϵ' / ϵ_0	3.11	3.09	3.05	3.02	3.01	2.96	2.90	2.77	2.74
Ethocell LT5 ^c		tan δ	75	65	63	76	113	150	160	170	210
Lumarith #22361 ^d	24	ϵ' / ϵ_0	3.10	3.06	3.02	2.99	2.92	2.87	2.80	----	2.74
		tan δ	48	48	52	67	115	158	160	----	196
	84	ϵ' / ϵ_0	3.00	3.00	2.90	2.85	2.80	2.80	2.80	----	2.79
		tan δ	78	70	66	66	90	140	200	----	402
- 25 -											
i. Silicone Resins											
Formica G7 ^e	25	ϵ' / ϵ_0	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73
(field I laminate)		tan δ	17	16	15	14	12	15	19		
(field II laminate)	25	ϵ' / ϵ_0	5.18	4.72	4.37	4.09	3.99	3.95	3.94	3.92	3.90
Formica G6 ^e	25	ϵ' / ϵ_0	3.99	3.91	3.87	3.85	3.82	3.82	3.82	3.81	3.74
(field II laminate)		tan δ	210	110	96	130	46	22	40	55	45
(field I laminate)	25	ϵ' / ϵ_0	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.74
		tan δ	13	11.5	10.5	10	10.5	13.3	51	61	

a. 8% plast. (Celanese). b. 25% camphor (DuPont). c. Dow. d. 13% plast. (Celanese). e. Fiberglas laminate (Formica).

I. Solids, B. Organic 3. Plastics (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	$\frac{1}{T}^{\circ}\text{C}$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{1x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$
1. Silicon Resins (cont.)										
DC 996 cured 16 hrs. at 150 $^{\circ}\text{C}^{\text{a}}$	25	ϵ'/ϵ_0	3.08	3.04	3.02	3.01	2.99	2.98	2.96	
tan δ	83	74	65	52	42	38	31			
DC 996 cured 16 hrs. at 250 $^{\circ}\text{C}^{\text{a}}$	25	ϵ'/ϵ_0	2.90	2.90	2.90	2.90	2.90	2.90	2.90	
tan δ	14	15	16.5	17.5	18	17	16.5			
DC 2101 ^b	24	ϵ'/ϵ_0	2.90	2.90	2.90	2.90	2.90	2.90	2.90	
(discontinued)										
Polyglass S ^c	24	ϵ'/ϵ_0	3.60	3.59	3.58	3.57	3.57	3.56	3.55	3.53
tan δ	70	56	49	46	45	45	45			
tan δ	11	11	12	13	15	19	----	3.55	3.53	
80	ϵ'/ϵ_0	3.60	3.59	3.58	3.57	3.57	3.56	3.55	3.53	
tan δ	27	17	11	10	10	14	----	40	46	
Molding Compound XM-3 ^d	25	ϵ'/ϵ_0	4.03	4.00	3.99	3.98	3.95	3.93	3.92	3.91
tan δ	51	52	50	47	38	42	50	50	46	49
Dilecto (Silicone Glass laminate) GB-2615 (field \perp sheet) ^e	25	ϵ'/ϵ_0	3.83	3.82	3.81	3.80	3.80	3.79	3.79	3.85
tan δ	12.8	13	13	12.3	12.9	14.8	14.8	14.8	14.8	14.8
90	ϵ'/ϵ_0	3.74	3.73	3.71	3.69	3.63	3.56	3.55	3.55	3.55
tan δ	21	20	8.5	21	39	26				
200	ϵ'/ϵ_0	3.50	3.62	3.44	3.42	3.40	3.35			
tan δ	339	74.7	32.6	22.7	31.4	30				
(field II sheet)	25	ϵ'/ϵ_0	4.97	4.48	4.43	3.95	3.92	3.87	3.87	3.76
tan δ	580	560	440	185	55	29	23	42	57	78
220	ϵ'/ϵ_0	4.68	4.26	4.18	4.18	----	----	----	3.87**	
tan δ	1620	526	300	195	----	----	----	75**		
25*	ϵ'/ϵ_0	4.05	3.93	3.90	3.85	----	----	----		
tan δ	104	60	42	31	----	----	----			

a. Methyl, phenyl, and methyl phenyl polysiloxane resin (Dow Corning). b. Cross-linked organo-siloxane polymer (Dow Corning).

c. 16% DC 2101, 84% Corning's 790 glass powder (Lab. Ins. Res.). d. 35% methyl and phenyl polysilicone resin, 45% glass fibers, 19% silica filler (Dow Corning). e. 50% DC-2103, 50% staple fibre glass base (Cont. Diamond).

*After temperature run. ** 200 $^{\circ}\text{C}$.

I. Solids B. Organic 3. Plastics (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	$\frac{1}{\epsilon' / \epsilon_0}$	$\frac{1x10^2}{\epsilon' / \epsilon_0}$	$\frac{1x10^3}{\epsilon' / \epsilon_0}$	$\frac{1x10^4}{\epsilon' / \epsilon_0}$	$\frac{1x10^5}{\epsilon' / \epsilon_0}$	$\frac{1x10^6}{\epsilon' / \epsilon_0}$	$\frac{1x10^7}{\epsilon' / \epsilon_0}$	$\frac{1x10^8}{\epsilon' / \epsilon_0}$	$\frac{1x10^9}{\epsilon' / \epsilon_0}$	$\frac{3x10^9}{\epsilon' / \epsilon_0}$	$\frac{1x10^10}{\epsilon' / \epsilon_0}$	$\frac{2.5x10^{10}}{\epsilon' / \epsilon_0}$
1. <u>Silicone Resins</u>												
(Cmt.)												
Dilecto (silicone glass)	25	ϵ' / ϵ_0	3.56	3.56	3.56	3.55	3.54	3.54	3.54	3.54	3.54	3.54
lamina :e) GB 1125 ^a		tan δ	13.5	12.9	12.9	11.1	8.5	11.4	11.4	18.6		
(field \perp sheet)												
	90	ϵ' / ϵ_0	3.41	3.39	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38
		tan δ	26.4	16.2	14.9	16.1	11	11	11	9.8		
	200	ϵ' / ϵ_0	3.18	3.18	3.18	3.17	3.15	3.15	3.10			
(field \parallel sheet)		tan δ	236	43	23	195	21	15.4				
	25	ϵ' / ϵ_0	6.55	5.72	4.94	3.96	3.84	3.82	3.80	3.78	3.76	3.70
		tan δ	1250	910	1080	516	128	37	25	39	52	87
	215	ϵ' / ϵ_0	10.93	8.60	6.65	4.92	-----	-----	-----	-----	3.78	
		tan δ	2900	280	1800	1410	-----	-----	-----	-----	-----	80
	25*	ϵ' / ϵ_0	5.71	5.15	1.54	3.98						
		tan δ	624	880	940	640						
DC 2103 Lamine (XL-48) ^b	25	ϵ' / ϵ_0	3.94	3.92	3.93	3.90	3.90	3.90	3.88	3.88**	3.88**	
		tan δ	18	16	15	14	16	26	37	37	67**	99**
Taylor Grade CSC ^c	25	ϵ' / ϵ_0	5.07	4.14	4.11	4.04	4.03	4.01	-----	3.91	3.90	3.85
(field \parallel laminate)		tan δ	99	72	83	44	20	15	-----	30	39	40
(Field \perp laminate)												
	25	ϵ' / ϵ_0	3.78	3.77	3.77	3.77	3.77	3.74	3.74			
		tan δ	13.4	12.5	11	9.5	9.3	11.9	18			
Taylor Grade CSS ^d	25	ϵ' / ϵ_0	4.10	4.00	3.94	3.94	3.94	3.94	3.94	3.92	3.92	3.75
(field \parallel laminate)		tan δ	160	160	100	34	21	20	30	44	55	63
(field \perp laminate)												
	25	ϵ' / ϵ_0	3.74	3.74	3.74	3.74	3.74	3.74	3.74			
		tan δ	15	14	13	12	13	15	22			
DC 2104 Lamine (XL-269) ^e	25	ϵ' / ϵ_0	4.14	4.14	4.13	4.13	4.13	4.11	4.10	4.07**	4.05**	
		tan δ	32	29	26	22	22	29	34	34	71**	83**
J. Polyvinyl Resins												
1. Polyethylene												
Polyethylene DE-3401 ^f	25	ϵ' / ϵ_0	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26
		tan δ	< 2	< 2	< 2	< 2	< 2	< 2	< 2	-----	3.1	3.6
Polythene A-3305 ^g	24	ϵ' / ϵ_0	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
(Now replaced by		tan δ	5	< 3	< 3	< 5	< 4	< 3	-----	3	4	6.7
Alethon)												
	80	ϵ' / ϵ_0	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.20
		tan δ	< 5	< 3	< 3	< 5	< 4	< 3	-----	7.2	8.5	

a. 50% DC-2103, 50% continuous-filament Glass base (Cont. Diamond). b. 45% methyl and phenyl polysiloxane resin, 55% ECC-261 Fiberglas (Dow-Corning). c. 45-50% DC-2103, 50-55% cont.-filament Glass cloth (Taylor). d. 45-50% DC-2103, 50-55% staple fibre glass cloth (Taylor). e. 35% methyl and phenyl polysiloxane resin, 65% ECC-181 fiberglas (Dow-Corning). f. 0.1% antioxidant (Bakelite). g. 100% polyethylene (DuPont).

*Measured after temperature run. **field \parallel laminate, at other frequencies field \perp sheet.

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.)

		Values for tan δ are multiplied by 10^4 ; frequency given in c/s.							
		$\frac{1 \times 10^3}{T^{\circ C}}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{tan \delta}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{tan \delta}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{tan \delta}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$
1) <u>Polyethylene</u> (cont.)									
Polyethylene ^a	23	ϵ' / ϵ_0	2.25	2.25	2.25	2.25	2.25	2.25	2.25
milled 3', 125°C		tan δ	< 2	< 2	< 2	< 2	< 2	< 2	< 2
milled 30', 125°C	23	ϵ' / ϵ_0	2.26	2.26	2.26	2.26	2.26	2.26	2.26
milled 30', 125°C		tan δ	< 5	5	6	7	8	9	10
milled 30', 190°C	-12	ϵ' / ϵ_0	2.38	2.37	2.36	2.35	2.35	2.34	2.33
		tan δ	24	21	19	18	21	28	39
23	ϵ' / ϵ_0	2.38	2.37	2.36	2.36	2.35	2.34	2.33	2.32
	tan δ	28	28	27	27	28	30	42	51
2) <u>Polyisobutylene</u> ^b									
Polyisobutylene ^b	25	ϵ' / ϵ_0	2.23	2.23	2.23	2.23	2.23	2.23	2.23
Run 5047-2		tan δ	4	1	1	< 2	1	1	3
Copolene B ^c	25	ϵ' / ϵ_0	2.3	2.3	2.3	2.3	2.3	2.3	2.3
		tan δ	16	8	4	1	1	7	14
3) <u>Polyvinyl chloride-</u> <u>acetate</u> ^d									
Vinylite QYNA ^d	20	ϵ' / ϵ_0	3.18	3.10	3.02	2.96	2.88	2.87	2.85
		tan δ	130	185	225	210	160	115	81
47	ϵ' / ϵ_0	3.60	3.52	3.41	3.28	3.14	3.02	2.92	2.81
		tan δ	100	166	240	261	228	162	110
76	ϵ' / ϵ_0	3.92	3.83	3.68	3.3	3.0	2.87	2.8	2.8
		tan δ	180	220	320	400	350	270	190
96	ϵ' / ϵ_0	6.60	5.30	4.40	3.7	3.3	2.8	2.7	2.7
		tan δ	1500	1400	1200	980	740	500	320
110	ϵ' / ϵ_0	9.9	8.6	6.8	5.6				
		tan δ	1030	1330	1780	1900			
Vinylite VG-5544 ^e	25	ϵ' / ϵ_0	7.72	7.20	6.40	5.25	4.13	3.45	3.05
		tan δ	570	640	1060	1500	1550	1200	650
Vinylite VG-59C1, black ^f	25	ϵ' / ϵ_0	6.5	5.5	4.6	3.9	3.4	3.1	3.0
		tan δ	1020	1180	1190	1000	740	500	280

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a. Bakelite. b. 100% Esso Lab.). c. 61% polyisobutylene B-100, 39% Marbon B (Am. Phenolic). d. 100% polyvinyl chloride (Bakelite).

e. 40% polyvinyl chloride-acetate, 40% plast., 14% misc. (Bakelite). f. 62.5% polyvinyl chloride-acetate, 29% plast., 8.5% misc. (Bakelite).

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	3) Polyvinyl chloride (cont.)	$T^\circ C$	1×10^{-2}	1×10^{-3}	1×10^{-4}	1×10^{-5}	1×10^{-6}	1×10^{-7}	1×10^{-8}	3×10^{-9}	1×10^{-10}	2×10^{-10}
Vinylite VG-5904, black ^a	ϵ'/ϵ_0 25	8.1	7.5	6.6	5.4	4.3	3.7	3.3	3.1	2.94	2.83	
	tan δ	550	710	1060	1390	1400	1100	670	500	340	320	
Vinylite VU-1900, clear ^b	ϵ'/ϵ_0 24	6.55	5.65	4.70	3.90	3.30	2.95	2.80	----	2.65	2.62	2.62
	tan δ	1060	1150	1300	1180	880	560	310	----	131	104	110
	ϵ'/ϵ_0 79	10.3	8.15	7.5	6.5	5.5	4.3	3.4	----	2.84	2.60	
Vinylite VHH ^c	ϵ'/ϵ_0 22	3.20	3.12	3.06	3.00	2.91	2.88	2.83	----	498	351	
	tan δ	100	130	155	150	140	110	90	----	76		
	ϵ'/ϵ_0 47	3.56	3.48	3.38	3.27	3.16	3.02	2.9	----	2.79		
Vinylite VMS ^d	ϵ'/ϵ_0 26	3.10	3.10	3.08	3.02	2.95	2.90	2.85	2.8	----	2.74	
	tan δ	110	142	190	227	206	152	114	----	92		
Vinylite VYN ^e	ϵ'/ϵ_0 20	3.20	3.15	3.05	2.96	2.90	2.84	2.8	----	63		
	tan δ	115	140	170	170	140	105	80	----	2.74		
Geon 2046 ^f	ϵ'/ϵ_0 23	6.95	6.10	5.05	4.13	3.55	3.15	3.00	2.97	2.89	2.83	
	tan δ	820	1100	1320	1200	890	570	300	211	116	116	
	ϵ'/ϵ_0 80	9.1	8.8	8.3	7.6	6.5	5.0	4.0	----	3.06	2.90	
Geon 80365 ^g	ϵ'/ϵ_0 25	3.67	3.65	3.58	3.52	3.42	3.39	3.34	----	484	328	
	tan δ	68	95	133	145	130	115	120	----			
Geon 80384 ^h	ϵ'/ϵ_0 25	3.43	3.34	3.23	3.14	3.05	3.06	3.05	----			
	tan δ	120	184	224	217	158	114	101	----			

a. 54% polyvinyl chloride-acetate, 41% plast., 5% misc. (Bakelite). b. 64.5% polymer of 95% vinyl chloride and 5% vinyl acetate, 32% Flexol D.O.P., 3.5% misc. (Bakelite). c. Polymer of 87% vinyl chloride and 13% vinyl acetate (Bakelite). d. Polymer of 91% vinyl chloride and 9% vinyl acetate (Bakelite). e. Polymer of 95% vinyl chloride and 5% vinyl acetate (Bakelite). f. 50% polyvinyl chloride, 30% dioctyl phosphate, 6% stabilizer, 5% filler (Goodrich). g. 71% polyvinyl chloride, 10.5% filler, 5% plasticizer, 8.5% stabilizer (Goodrich). h. 87.8% polyvinyl chloride, 10.5% stabilizer (Goodrich).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

3) Polyvinyl Chloride (cont.)	<u>T_C</u>	<u>ϵ'/ϵ_0</u>	<u>$1x10^2$</u>	<u>$1x10^3$</u>	<u>$1x10^4$</u>	<u>$1x10^5$</u>	<u>$1x10^6$</u>	<u>$1x10^7$</u>	<u>$1x10^8$</u>	<u>$3x10^8$</u>	<u>$3x10^9$</u>	<u>$1x10^{10}$</u>
Koroseal 5CS-243 ^a	27	ϵ'/ϵ_0	6.1	5.65	5.00	4.15	3.60	3.20	2.9	---	2.73	2.62
		tan δ	790	1000	1300	1250	930	560	300	---	112	120
Lucoflex ^b	25	ϵ'/ϵ_0	---	---	---	---	---	---	---	2.75		
		tan δ	---	---	---	---	---	---	---	170		
Polyvinyl chloride 1006 ^c	25	ϵ'/ϵ_0	6.1	---	4.55	---	3.3					
		tan δ	760	---	1100	---	760					
Polyvinyl chloride 1018 ^d	25	ϵ'/ϵ_0	6.2	---	4.95	---	3.15					
		tan δ	630	---	950	---	920					
Polyvinyl chloride 1216 ^e	25	ϵ'/ϵ_0	6.1	---	4.4	---	3.2					
		tan δ	1170	---	1110	---	450					
Polyvinyl chloride 1406 ^f	25	ϵ'/ϵ_0	6.05	---	4.5	---	3.6					
		tan δ	870	---	940	---	480					
Ultron Wire Compound	25	ϵ'/ϵ_0	3.31	3.22	3.10	2.98	2.85					
UL300 ^g		tan δ	150	210	250	220	155					
Ultron Wire Compound	25	ϵ'/ϵ_0	6.4	---	4.65	---	3.3					
UL1004 ^h		tan δ	810	---	1210	---	740					
Ultron Wire Compound	25	ϵ'/ϵ_0	6.7	---	4.7	---	3.5					
UL2 4001 ^k		tan δ	1100	---	1210	---	700					
Polyvinyl chloride	25	ϵ'/ϵ_0	5.45	4.77	4.17	3.75	3.52	3.25	3.00			
W-174 ^m		tan δ	815	930	880	740	550	425	415			
Polyvinyl chloride	25	ϵ'/ϵ_0	5.94	5.20	4.51	3.90	3.44	3.37	3.04			
W-175 ⁿ		tan δ	840	960	865	580	430	360				
Polyvinyl chloride	25	ϵ'/ϵ_0	6.21	5.52	4.70	3.96	3.53	3.28	3.00			
W-176 ^p		tan δ	730	940	1070	960	720	520	500			

a. 63.7% polyvinyl chloride, 33.1% di-2-ethylhexylphthalate, lead silicate (Goodrich). b. Unplasticized polyvinyl chloride (Lucoflex Plastic). c. 57.5% polymer, 12.6% fillers, 28.7% plasticizers (Monsanto). d. 52.1% polymer, 15.1% fillers, 31.4% plasticizers (Monsanto). e. 57.5% polymer, 10.4% fillers, 31.6% plasticizers (Monsanto). f. 59.4% polymer, 10.7% fillers, 29.7% plasticizers (Monsanto). g. 100% polymer (Monsanto). h. 64.7% polymer, 2% filler, 32.5% plasticizers (Monsanto). k. 60.1% polymer, 7.8% fillers, 31.2% plasticizers (Monsanto). n. 65% Geon 101, 35% Paraplex G-25 (Rohm and Haas). p. 65% Geon, 35% Paraplex G-60 (Rohm and Haas).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

3) Polyvinyl Chloride (cont.)		T_g^o	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$
Plasticell ^a	25	ϵ' / ϵ_0	1.04	1.04	1.04	1.04	1.04	1.04	1.04*	1.04*	1.04	1.04
	tan δ	21	11	< 15	< 15	10	10	10	10*	18*	55	50
Knsolite M22240 ^b	25	ϵ' / ϵ_0	1.51	1.36	1.29	1.24	1.16					
	tan δ	3200	610	330	340	420						
Ensolite M22239 ^b	25	ϵ' / ϵ_0	1.48	1.40	1.31	1.25	1.20					
	tan δ	2850	770	280	250	340						
Ensolite 3036 ^b (field \perp plane of sample)	25	ϵ' / ϵ_0	1.30	1.24	1.19	1.17	1.16					
(field \parallel plane of sample)	25	ϵ' / ϵ_0	-----	-----	187	137	111					
	tan δ	-----	-----	-----	-----	-----						

4) Polyvinylidene and

Vinyl chloride		T_g^o	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$
Saran B-115 ^c	23	ϵ' / ϵ_0	4.88	4.65	4.17	3.60	3.18	2.97	2.82	-----	2.71	2.70
	tan δ	450	630	885	845	570	310	180	-----	-----	72	51
	ϵ' / ϵ_0	5.13	4.94	4.85	4.71	4.40	3.75	3.2	-----	-----	2.76	242
	tan δ	800	210	130	320	780	1300	900	-----	-----		

5) Polychlorotrifluoro-

<u>ethylene</u>		T_g^o	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$
Kel-F ^d	26	ϵ' / ϵ_0	2.72	2.63	2.53	2.46	2.43	2.35	-----	2.30	2.29	2.29
	tan δ	210	270	230	135	82	60	-----	30	28	39	55
Kel-F Grade 300 ^d (field \perp laminate)	25	ϵ' / ϵ_0	2.82	2.76	2.65	2.50	2.46	2.42	2.36	2.35	2.34	2.33
	tan δ	148	225	212	140	96	75	54	51	66	59	
Kel-F Grade 300-P25 ^e	25	ϵ' / ϵ_0	2.84	2.75	2.68	2.58	2.51	2.45	2.37	2.35	2.31	2.26
	tan δ	126	207	234	204	175	214	186	150	93	93	

6) Polytetrafluoro-

ethylene

Dilecto (Teflon Laminate)		T_g^o	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$
CB-112F ^f	250	ϵ' / ϵ_0	2.48	2.46	2.46	2.46	2.46	2.46	-----	2.44	2.44	2.44
	tan δ	80	36	18	14	14	14	14	-----	2.5	2.5	2.5
	ϵ' / ϵ_0	2.70	2.68	2.69	2.69	2.69	2.69	2.69	-----	2.69	2.69	2.69
	tan δ	4.7	3.9	4.7	4.8	4.8	4.8	4.8	-----	4.8	4.8	4.8

a. Expanded polyvinyl chloride (Sponge Rubber). b. Modified polyvinyl chloride (U. S. Rubber). c. Polyvinylidene and vinyl chlorides (Dow). d. d. Polychlorotrifluoroethylene (Kodak). e. Plasticized polychlorotrifluoroethylene (Kodak). f. 65-68% Teflon, 32-35% continuous-filament glass base (Cont. Diamond).

I.. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

		$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\tan \delta}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\tan \delta}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\tan \delta}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\tan \delta}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\tan \delta}$
6) Polytetrafluoro-											
ethylene (cont.)	T ^o C										
Dilecto (Teflon Laminate	25	ϵ'/ϵ_0	3.35	3.24	3.18	3.17	3.16	3.15	3.15**	3.15	3.10
GB-112T) ^a		$\tan \delta$	361	245	169	108	42	23	24	31**	38
(field II laminate)	250	ϵ'/ϵ_0	---	---	---	---	---	---	---	3.10	47
		$\tan \delta$	---	---	---	---	---	---	---	70	
	25*	ϵ'/ϵ_0	3.26	3.25	3.24	3.21					
		$\tan \delta$	66	14.3	17.3	27					
Teflon ^b	22	ϵ'/ϵ_0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.08	2.08
		$\tan \delta$	< 5	< 3	< 3	< 3	< 2	< 2	< 2	3.7	6
	100	ϵ'/ϵ_0	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	
		$\tan \delta$	10	4	2	< 3	< 2	< 2	< 2	5.1	
Chemelac ML405 ^c	25	ϵ'/ϵ_0	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
		$\tan \delta$	18	5.1	2.7	3	5	7.2	9	8	6.8
Chemelac ML406 ^d	25	ϵ'/ϵ_0	---	---	---	170	72	---	---	12.7	
		$\tan \delta$ ***	---	>10000	2400	62	---	---	---	33	
	p	---	520	520	440	410	---	---	---	145	
Chemelac ML407 ^e	25	ϵ'/ϵ_0	3.42	3.02	2.85	2.74	2.71	2.65	2.63		
		$\tan \delta$	917	700	350	180	150	147	158		
Chemelac ML411 ^f	25	ϵ'/ϵ_0	2.14	2.14	2.14	2.14	2.14	2.14	2.14		
(field I sheet)		$\tan \delta$	18.5	9.6	7	6.8	7	9.2	10		
(field II sheet)	25	ϵ'/ϵ_0	---	---	---	---	---	---	---	2.52	2.50
		$\tan \delta$ ***	---	---	---	---	---	---	---	25	28
Chemelac ML412 ^g	25	ϵ'/ϵ_0	---	2.35	---	---	---	---	---	2.35	
		$\tan \delta$	---	12	---	---	---	---	---	15	
Chemelac ML414 ^h	25	ϵ'/ϵ_0	---	---	---	---	150	43	---	33	
		$\tan \delta$ ***	---	>10000	>10000	>1000	>100	11.8	4.8	3.9	
	p	---	---	95	95	95	95	80	---	4.8	

a. 65-68% Teflon, 32-37% continuous-filament glass base (Cont. Diamond). b. Polytetrafluoroethylene (DuPont). c. 75% Teflon, 25% calcium fluoride (U.S.Gasket). d. 80% Teflon, 20% carbon (U.S. Gasket). e. 88% Teflon, 12% ceramic (U.S.Gasket). f. 75% Teflon, 25% Fiberglas (U.S.Gasket). g. 75% Teflon, 25% glass (U.S.Gasket). h. 75% Teflon, 25% graphite (U.S.Gasket).

*After temperature run. **Freq. = 1×10^9 . ***tan δ not multiplied by 10^4 .

I. Solids, B. Organic 3. Plastics J. Polyvinyl resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

		$\frac{1}{T_C}$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$
6) Polytetrafluoro-													
ethylene (cont.)													
Chemelac M1418-2 ^a	25	ϵ'/ϵ_0	2.30	2.20	2.20	2.15	2.15	2.14	2.14	2.14	2.14	2.14	2.14
(desiccated 48 hrs. P ₂ O ₅)													
(dried in oven)	25	ϵ'/ϵ_0	2.	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
Chemelac M1418-5 ^b	25	ϵ'/ϵ_0	2.27	2.23	2.18	2.18	2.16	2.16	2.16	2.16	2.16	2.16	2.16
tan δ	450		118	32	8.8	5.7	5.9	7.1					
Chemelac M1422 ^c	25	ϵ'/ϵ_0	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
tan δ	11.9		7.7	4.5	2.8	2.0	1.8	2.4					
Chemelac M1423 ^d	25	ϵ'/ϵ_0	---	1.308	---	---	---	---	---	---	---	---	1.30
tan δ	---		1.81	---	---	---	---	---	---	---	---	---	62

7) Polyvinyl alcohol-

acetate

Elvanol 51A-05 ^e	25	ϵ'/ϵ_0	8.2	7.8	7.2	6.2	5.2	4.5	---	---	3.74	3.50	3.46
tan δ	430		440	580	720	900	1000	---	---	---	550	502	620
85	ϵ'/ϵ_0	400	100	33	16	10	7.3	---	---	4.67			
tan δ	15000		13000	9000	3600	2300	2000	---	---	1770			
Elvanol 50A-42 ^f	23	ϵ'/ϵ_0	14.0	10.4	8.0	6.6	5.7	5.0	---	---	3.75		
tan δ	4050		1850	1150	1000	950	900	---	---	715			
68	ϵ'/ϵ_0	85	26	14	9.5	7.5	5.8	---	---	---			
tan δ	9600		8100	4000	1600	1400	1500	---	---	5.6	4.1		
100	ϵ'/ϵ_0	3000	400	50	18	13	8.7	---	---	2300	3000		
tan δ	15000		22000	20000	4800	2700	2600	---	---	4.12			
Elvanol 70A-05 ^f	26	ϵ'/ϵ_0	---	---	58	27	14	7	---	840			
tan δ	---		---	8200	5900	4100	2700	---	---	640	636	730	
Elvanol 72A-51 ^f	26	ϵ'/ϵ_0	---	---	45.5	22.0	12.5	7.5	---	3.89	3.8		
tan δ	---		7600	5100	3500	2500	2000	---	---	2.88			
Elvacet 42A-900 ^g	25	ϵ'/ϵ_0	3.09	3.07	3.05	3.02	2.98	2.94	2.90	---	2.8		
tan δ	49		50	52	56	65	49	37	---	28			
85	ϵ'/ϵ_0	7.3	7.15	5.9	3.75	3.25	2.95	2.90	---	2.87			
tan δ	180		590	2400	1830	830	560	200	---	85			

a. 90% Teflon, 10% quartz (U.S.Gasket). b. 75% Teflon, 25% quartz (U.S.Gasket). c. 80% Teflon, 20% titanium dioxide (U.S.Gasket).

d. Air-filled Teflon (U.S.Gasket). e. Polyvinyl acetate-acetoxy (DuPont). f. Polyvinyl alcohol-acetate, 11-14% acetoxy (DuPont). g. Polyvinyl acetate (DuPont).

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

			<u>$\frac{1x10^2}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^3}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^4}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^5}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^6}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^7}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^8}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{3x10^9}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^0}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{3x10^0}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^0}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{2.5x10^{10}}{\epsilon'/\epsilon_0}$</u>	
8) <u>Polyvinyl acetals</u>	T°C														
Forvar, Type E ^a	26	ϵ'/ϵ_0	3.16	3.12	3.08	3.00	2.92	2.85	-----	-----	2.76	-----	2.7	-----	
	tan δ	54	100	154	190	190	165	-----	-----	-----	113	-----	115	-----	
88	ϵ'/ϵ_0	3.55	3.5	3.4	3.25	3.1	2.95	2.85	-----	-----	2.80	-----			
	tan δ	60	83	102	145	213	310	300	-----	-----	227	-----			
Alvar 11/90 ^b	25	ϵ'/ϵ_0	3.17	3.14	3.09	3.03	2.96	2.90	2.82	2.80	2.73	2.70	2.65	-----	
	tan δ	65	70	100	140	180	160	125	119	136	175	175	175	175	
84	ϵ'/ϵ_0	3.84	3.54	3.40	3.25	3.05	2.90	-----	-----	-----	2.74	-----			
	tan δ	575	390	270	195	180	225	-----	-----	-----	196	-----			
Bulvar, Low OH ^c	27	ϵ'/ϵ_0	2.69	2.67	2.65	2.63	2.61	2.59	-----	-----	2.51	2.48	2.46	-----	
	tan δ	38	40	56	88	124	138	-----	-----	-----	111	107	99	99	
Butvar 55/98 ^c	27	ϵ'/ϵ_0	3.04	3.02	2.98	2.94	2.86	2.75	2.67	2.67	2.62	2.62	2.62	2.62	2.62
	tan δ	41	59	108	161	215	216	177	177	177	172	172	172	172	172
9) <u>Polyacrylates</u>															
Lucite HM-119 ^d (now replaced by HM-140)	-12	ϵ'/ϵ_0	3.0	2.9	2.8	2.7	2.63	2.60	2.59	2.59	2.58	2.57	2.57	2.57	2.57
	tan δ	330	250	190	140	102	70	55	55	55	35.4	34	34	34	34
23	ϵ'/ϵ_0	3.20	2.84	2.75	2.68	2.63	2.60	2.58	2.58	2.58	2.57	2.57	2.57	2.57	2.57
	tan δ	620	440	315	220	145	100	67	67	67	51.3	49	49	49	49
81	ϵ'/ϵ_0	3.97	3.45	3.08	2.86	2.72	2.62	2.59	2.59	2.59	2.58	2.57	2.57	2.57	2.57
	tan δ	600	820	720	540	380	220	130	130	130	77	75	75	75	75
Lucite, Sintered ^e (obsolete)	27	ϵ'/ϵ_0	2.29	2.12	2.01	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Gafite cast polymer ^f (sheet sample)	25	ϵ'/ϵ_0	3.25	3.12	3.02	2.97	2.90	2.88	2.83	2.83	64	64	64	64	64
(rod sample)	25	ϵ'/ϵ_0	---	---	---	---	---	---	---	---	2.75	2.75	2.75	2.75	2.75
Plexiglass	27	ϵ'/ϵ_0	3.40	3.12	2.95	2.84	2.76	2.71	2.71	2.71	2.66	2.60	2.59	2.59	2.59
	tan δ	605	465	300	200	140	100	67	67	67	62	57	57	57	57
80	ϵ'/ϵ_0	4.30	3.80	3.34	3.00	2.80	2.70	2.70	2.70	2.70	2.56	2.56	2.56	2.56	2.56
	tan δ	700	895	800	520	320	210	177	177	177	172	172	172	172	172

a. Polyvinyl formal (Shawinigan). b. Polyvinyl acetal (Shawinigan). c. Polyvinyl butyral (Shawinigan). d. Polymethyl methacrylate (DuPont). e. DuPont. f. Methyl and alpha-chloroacrylate (Gen. Aniline). g. Polymethyl methacrylate (Rohm and Haas).

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

<u>9) Polyacrylates</u> (cont.)	$T^{\circ}C$	ϵ'/ϵ_0	<u>1×10^2</u>	<u>1×10^3</u>	<u>1×10^4</u>	<u>1×10^5</u>	<u>1×10^6</u>	<u>1×10^7</u>	<u>1×10^8</u>	<u>3×10^8</u>	<u>3×10^9</u>	<u>1×10^{10}</u>	<u>2.5×10^{10}</u>
Polyethyl methacrylate ^a	22	ϵ'/ϵ_0	2.90	2.75	2.65	2.60	2.55	2.53	-----	-----	2.51	2.50	2.5
		$\tan \delta$	420	294	185	118	90	75	-----	-----	75	97	83
	80	ϵ'/ϵ_0	3.87	3.36	2.86	2.70	2.61	2.57	2.55	-----	2.49	2.48	-----
		$\tan \delta$	810	1060	960	710	400	260	140	-----	91	135	-----
Polybutyl methacrylate ^a	-12	ϵ'/ϵ_0	2.50	2.46	2.44	2.42	2.41	2.40	-----	-----	2.38	-----	-----
		$\tan \delta$	190	120	68	42	33	25	-----	-----	48	-----	-----
	24	ϵ'/ϵ_0	2.82	2.62	2.52	2.47	2.43	2.42	-----	-----	2.38	2.36	46
		$\tan \delta$	605	360	200	125	80	55	-----	-----	44	-----	-----
	81	ϵ'/ϵ_0	3.70	3.52	3.14	2.82	2.60	2.48	-----	-----	2.39	-----	-----
		$\tan \delta$	150	650	1200	980	470	220	-----	-----	185	-----	-----
Polyisobutyl methacrylate ^a	25	ϵ'/ϵ_0	2.70	2.68	2.63	2.55	2.45	2.45	2.42	2.40	2.39	2.38	2.37
		$\tan \delta$	111	70	50	37	35	46	52	47	31	39	52
	80	ϵ'/ϵ_0	2.9	2.7	2.5	2.5	2.44	2.42	2.42	2.40	2.39	2.38	-----
		$\tan \delta$	830	600	360	210	100	80	70	65	54	59	-----
Polycycloteryl methacrylate ^b	25	ϵ'/ϵ_0	2.58	2.52	2.52	2.52	2.48	2.47	-----	2.46	-----	2.46	-----
		$\tan \delta$	46	47.5	60	50	28	23	25	-----	34.9	-----	41
	84	ϵ'/ϵ_0	2.63	2.60	2.55	2.47	2.42	2.39	2.37	-----	2.37	-----	-----
		$\tan \delta$	150	124	98	81	68	38	32	-----	49	-----	-----

10) Polystyrene
c
(commercially molded)

Sheet Stock

25	ϵ'/ϵ_0	2.56	2.56	2.56	2.56	2.56	2.55	2.55	2.55	2.55	2.54	2.54	2.54
	$\tan \delta$	< 0.5	< 0.5	< 0.5	0.5	0.7	< 2	< 1	3.5	3.3	4.3	3.3	4.3
80	ϵ'/ϵ_0	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.53	2.53	2.53
	$\tan \delta$	9	2	< 1	< 2	< 2	< 3	< 3	2.7	4.5	5.3	5.3	5.3

Rod Stock

Sample A	25	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	2.5	3.6	4.8	22
Sample B	25	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	12	-----	-----	16
Sample B	80	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

a. DuPont. b. Polaroid. c. For sheet stock, various samples used for different frequencies; for rod stock, ϵ'/ϵ_0 is the same as for sheet stock (Plax).

I. Solids. B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

10) Polystyrene (cont.)	T _g °C	ϵ'/ϵ_0	<u>1x10²</u>	<u>1x10³</u>	<u>1x10⁴</u>	<u>1x10⁵</u>	<u>1x10⁶</u>	<u>1x10⁷</u>	<u>1x10⁸</u>	<u>1x10⁹</u>	<u>1x10¹⁰</u>	<u>2.5x10¹⁰</u>
Styron C-176 ^a	25	ϵ'/ϵ_0	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.54
	tan δ	< 3	< 2	< 2	< 2	< 2	< 2	< 2	< 3	1.7	2.3	5.3
80	ϵ'/ϵ_0	2.55	-----	-----	-----	-----	-----	-----	-----	2.5	2.5	6.5
	tan δ	12	-----	-----	-----	-----	-----	-----	-----	5.0	6.5	6.5
Styron C-176, 30% humidity ^b	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	-----	2.54	2.54
Styron C-176, 50% humidity ^b	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	-----	3.2	3.2
Styron C-176, 90% humidity ^b	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	-----	2.54	2.54
Styron C-176 + 0.5% paraffin, 90% humidity ^b	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	4.9	4.9	4.9
Styron 411-A ^c (formerly Kep. Plastic Q-247)	22	ϵ'/ϵ_0	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.54	2.54
	tan δ	< 3	< 2	< 2	< 2	< 2	< 2	< 2	< 3	2.1	3.1	3.7
79	ϵ'/ϵ_0	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.54	2.54
	tan δ	12	2.5	< 2	< 2	< 2	< 2	< 2	3	-----	5.2	6
Styron 475 ^b	25	ϵ'/ϵ_0	2.62	2.61	2.59	2.56	2.56	2.56	2.55	2.53*	2.53	2.53
	tan δ	3.6	3.0	2.4	2.6	4.2	7.6	11	19*	36	36	17
Styron 666 ^b	25	ϵ'/ϵ_0	2.54	2.54	2.54	2.54	2.54	2.54	2.54*	2.53	2.53	2.52
	tan δ	1.75	1.1	< 1	< 1	.7	1.2	2	2.7*	3.1	3.1	3.4
Styron 671 ^b	25	ϵ'/ϵ_0	2.55	2.55	2.55	2.55	2.54	2.54	2.54*	2.54	2.54	2.54
	tan δ	.97	.64	< .5	< .5	.2	.38	.57	1.47*	1.76	1.76	2.1

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a. Polystyrene (Dow). Similar values given by Dow's C-244 and Q-247.1; Ostatlin's Localin #1 Color 4000; Bakelite's XMS-HA-621, XRS-23-B10012-442, XRS-23-B10012-520, XRS-23-B10016-D63, XRS-23-B10012-D107; Monsanto's Samples D-277, D-279 (extra purity), D-334.

b. Polystyrene (Dow). c. Polystyrene (Dow). Similar values given by Monsanto's Iustron Res. Sample D-276.
*Freq. = 1×10^9 .

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

		<u>10) Polystyrene</u>	<u>110²</u>	<u>110³</u>	<u>110⁴</u>	<u>110⁵</u>	<u>110⁶</u>	<u>110⁷</u>	<u>110⁸</u>	<u>3x10⁹</u>	<u>1x10¹⁰</u>	<u>2.5x10¹⁰</u>
(cont.)		<u>T^oC</u>	<u>1x10²</u>	<u>1x10³</u>	<u>1x10⁴</u>	<u>1x10⁵</u>	<u>1x10⁶</u>	<u>1x10⁷</u>	<u>1x10⁸</u>	<u>3x10⁹</u>	<u>1x10¹⁰</u>	<u>2.5x10¹⁰</u>
Fibers Q-107 ^a	26	ϵ'/ϵ_0	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.11	
		tan δ	7.6	6.3	4.6	3	3	3	4	4	6.3	
Foam Q-103, 90% humidity ^a	27	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	-----	1.03	
		tan δ	-----	-----	-----	-----	-----	-----	-----	-----	<0.3	
Styrofoam 103.7 ^b	25	ϵ'/ϵ_0	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
		tan δ	< 2	< 1	< 1	< 1	< 1	< 2	< 2	< 2	1	1.5
Polystyrene cast in vacuo ^c	25	ϵ'/ϵ_0	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
		tan δ	1	1	0.5	< 2	< 2	< 2	< 3	< 3	-----	2.4
Polystyrene cast in air ^c	25	ϵ'/ϵ_0	-----	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.48	2.48
		tan δ	-----	9	5.5	< 5	2	8	8	8	-----	12.8
Experimental Plastic Q764.6 ^a	25	ϵ'/ϵ_0	2.63	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.51*	2.51
		tan δ	2.5	1.3	1.8	2.5	2.3	1.4	2.8	7.3*	8.2	6.5
Experimental Plastic Q767.2 ^a	25	ϵ'/ϵ_0	2.98	2.95	2.92	2.90	2.86	2.83	2.80	2.77*	2.75	2.75
		tan δ	62	73	80	74	65	55	43	36*	38	43
Styramic #18 ^d	22	ϵ'/ϵ_0	2.68	2.66	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.63
		tan δ	29	18.4	5	< 2	< 2	< 2	1.6	1.9	2.2	2.3
	78	ϵ'/ϵ_0	2.7	2.7	2.67	2.65	2.65	2.65	2.65	2.65	2.63	2.63
		tan δ	91	67	25	6.5	4	4	3	3	2.0	2.0
<u>11) Misc. Polystyrenes</u>												
Exp. Plastic Q817.1 ^e	25	ϵ'/ϵ_0	2.60	2.60	2.60	2.60	2.59	2.58	2.57	2.57*	2.57	2.56
		tan δ	.7	.6	.61	.61	.7	1	2.1	4.8*	4.5	3
Exp. Plastic Q406 ^f	25	ϵ'/ϵ_0	2.60	2.59	2.58	2.57	2.56	2.55	2.52	2.50*	2.49	2.49
		tan δ	7.3	6.2	4.7	3.6	2.2	1.5	1.2	1.9*	2.0	2.6
Poly-p-Xylene ^g	25	ϵ'/ϵ_0	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45
		tan δ	2	3.4	3.9	< 2	0.7	3.7	3.7	3.7	3.7	9

a. Dow. b. 99.75% polystyrene, 0.25% filler (Dow). c. From Dow's N-100 styrene (Lab. Ins. Res.). d. 50% polystyrene, 50% chlorinated diphenyl (Monsanto). e. Poly alpha-methylstyrene (Dow). f. Polyvinyltoluene (Dow). g. Pressed fibers (Polaroid).

*Freq. = 1×10^9 .

I. Solids, S. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in cps.

	<u>12) Styrene copolymers</u>	<u>T°C</u>	<u>$\frac{1x10^2}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^3}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^4}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^5}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^6}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^7}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^8}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{3x10^9}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$</u>	<u>$\frac{2.5x10^{10}}{\epsilon'/\epsilon_0}$</u>
Styrene-2,4-dimethyl-	25	ϵ'/ϵ_0	2.53	2.53	2.53	2.53	2.52	2.52	2.52	2.51*	2.50	2.49
styrene copolymer ^a	tan δ	1.6	1.3	0.8	0.7	0.9	1.2	1.5	4.0*	5.4	2.8	
Styrene-acrylonitrile	25	ϵ'/ϵ_0	2.96	2.95	2.92	2.87	2.80	2.78	2.77	2.77*	2.77	2.76
copolymer ^a	tan δ	59	63	67	67	64	50	41	40*	41	45	
Darox copolymer 3 ^b	25	ϵ'/ϵ_0	2.53	2.53	2.52	2.51	2.50	2.49	2.49	----	2.48	2.45
Darox copolymer 4 ^{b,c}	25	ϵ'/ϵ_0	2.54	2.54	2.54	2.54	2.54	2.54	2.54	----	2.54	2.53
Darox copolymer X-3 ^d	25	ϵ'/ϵ_0	2.55	2.54	2.54	2.53	2.52	2.52	2.51	----	2.50	2.48
Darox copolymer X-4 ^b	25	ϵ'/ϵ_0	2.56	2.56	2.56	2.56	2.55	2.55	2.55	----	2.55	2.54
Styraloy 22 ^c	-12	ϵ'/ϵ_0	2.4	2.4	2.4	2.4	2.4	2.4	2.4	----	2.4	2.4
Styraloy 22 ^c	23	ϵ'/ϵ_0	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Marbon S ^d	25	ϵ'/ϵ_0	2.62	2.62	2.62	2.61	2.60	2.60	2.57	2.55*	2.55	2.54
Code 7206	tan δ	17.4	14.1	13.8	13.8	18.3	22.1	22.2	20.6*	20	19	
Marbon S-1	25	ϵ'/ϵ_0	2.55	2.55	2.54	2.54	2.54	2.53	2.52*	2.52	2.52	
Code 7254 ^d	tan δ	10	6	3.5	3.9	6.1	7.9	8.3	10*	11	12.5	
Marbon 8000 ^e	25	ϵ'/ϵ_0	2.56	2.56	2.56	2.56	2.56	2.56	2.52*	2.51	2.51	
Marbon 9200 ^f	25	ϵ'/ϵ_0	2.60	2.57	2.56	2.56	2.56	2.55	2.52*	2.52	2.52	
	tan δ	5.4	3.1	3	4.9	6.7	9	10	11.8*	11.9	11.5	

a. Am. Cyanamid. b. Dervay and Almy. c. Copolymer of butadiene and styrene (Dow). d. Butadiene-styrene copolymer, ca. 10% butadiene (Marbon). e. Butadiene-styrene copolymer ca. 15% butadiene (Marbon). f. Butadiene-styrene copolymer ca. 14% butadiene (Marbon).

*Freq. = 1×10^9 .

I. Solids, 3. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

12) Styrene copolymers,		$\frac{\epsilon_0}{\epsilon}$	$\frac{1x10^2}{\epsilon'}$	$\frac{1x10^3}{\epsilon'}$	$\frac{1x10^4}{\epsilon'}$	$\frac{1x10^5}{\epsilon'}$	$\frac{1x10^6}{\epsilon'}$	$\frac{1x10^7}{\epsilon'}$	$\frac{1x10^8}{\epsilon'}$	$\frac{1x10^9}{\epsilon'}$	$\frac{1x10^10}{\epsilon'}$	$\frac{2.5x10^10}{\epsilon'}$
<u>Linear (cont.)</u>		25	ϵ'/ϵ_0	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.55
Piccolastic D-125 ^a	tan δ	2		1.5	1	1	1	1.5	3	---	5	5
Styrene (50%) and 1,3,5-trivinyl-2,4,6-trichlorobenzene (50%) copolymer ^b	ϵ'/ϵ_0	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.66	2.65	2.65
Styrene (50%) and 1,4-di-2-vinyl-2,3,5,6-tetrachlorobenzene (50%) copolymer ^b	tan δ	8.5	8.9	9.7	10	11	16.2	26	20	21	21	19
S-60 ^c	ϵ'/ϵ_0	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
	tan δ	6	7.4	8.2	7.8	8.2	12.0	22	13.2	13.8	13.6	13.6
	ϵ'/ϵ_0	2.40	2.40	2.40	2.39	2.39	2.39	2.38	2.38	2.37	2.37	2.35
	tan δ	21	14	13	12	8	6	6	6	6.4	7.1	7.1
	ϵ'/ϵ_0	2.50	2.49	2.48	2.46	2.46	2.45	2.45	2.45	2.44	2.44	2.44
	tan δ	27	24	20	15	10	6	4	4	6.5	7.4	7.4

13) Styrene copolymers
cross-linked

Copolymer 8012 ^d	25	ϵ'/ϵ_0	2.58	2.58	2.58	2.58	2.57	2.55	2.54	2.53	2.52	2.52
Plastic MK2784 ^d	25	ϵ'/ϵ_0	2.59	2.59	2.59	2.59	2.56	2.56	2.55	2.54	2.54	2.52
Exp. Plastic Q-166 ^e	23	ϵ'/ϵ_0	3.44	3.40	3.38	3.36	3.32	3.22	3.05	---	2.71	2.62
	tan δ	45	55	70	110	180	350	420	---	315	250	
	ϵ'/ϵ_0	3.25	3.23	3.21	3.19	3.16	3.12	3.05	---	2.85	2.63	
	tan δ	550	95	41	38	55	110	250	---	570	550	
	ϵ'/ϵ_0	4.46	4.42	4.37	4.30	4.21	4.09	3.95	---	3.78	3.70	3.6
plus Fiberglas	79	ϵ'/ϵ_0	4.5	4.4	4.4	4.3	4.2	4.1	4.0	---	241	231
	tan δ	160	110	96	120	180	250	320	---	415	470	
	ϵ'/ϵ_0	2.55	2.55	2.55	2.55	2.55	2.55	2.55	---	2.55	2.55	2.54
Exp. Plastic Q-200.5 ^f	26	ϵ'/ϵ_0	4	< 2	< 2	2	2	3.4	4	5.2	---	24
	tan δ	100	ϵ'/ϵ_0	2.56	2.56	2.56	2.56	2.55	2.55	---	2.55*	
	tan δ	20	7	2	< 2	< 2	< 3	< 3	---	7.6*		

a. Methylstyrene-styrene copolymer (Penn. Ind. Chem.). b. Sprague (two different castings measured in the ranges 10^2 - 10^8 and 10^9 - 10^{10} c/s.) c. Standard Oil Dev. Co. N.J. d. Catalin. e. Dow. f. Cross-linked with o-, m-, p-divinylbenzenes (Dow).

*Measurements made at 78°C .

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.)

				$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$					
13) Styrene copolymers cross-linked (cont.)																			
Exp. Plastic Q-344 ^a	24	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.40	2.40	2.39	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.34	2.31	2.31				
		tan δ	11	20	50	20	9	7	7	7	7	7	9	8.6	10				
	80	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.4	2.4	2.39	2.38	2.38	2.38	2.38	2.38	2.35	2.35	2.33	2.31					
		tan δ	21	14	12	16	45	42	19	19	19	19	19	19	15				
Exp. Plastic Q-475.5 ^a	22	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.50	2.49					
		tan δ	4	2	2	4	7	9	9	9	9	9	9	9	8				
	80	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.47	2.47					
Pliolite S5 ^b	25	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.58	2.58	2.58	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.53*	2.51	2.51				
		tan δ	6.8	3.3	2.1	2.5	4.7	7.3	7.8	7.8	7.8	7.8	7.6*	7.2	6.7				
Pliolite S3 ^b	25	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.55*	2.52	2.52				
		tan δ	7.7	3.5	2.1	1.8	2.6	3.6	6.2	6.2	6.2	6.2	15*	8.8	7.5				
Pliolite S6 ^b	25	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.53*	2.52	2.51				
		tan δ	6	2.9	2.4	1.9	2	3.7	6.8	6.8	6.8	6.8	10.6*	11	8				
Pliolite S6 ^b	25	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.57	2.52	2.52				
		tan δ	6.6	2.8	2.1	2.1	2.1	3	5.5	16	16	16	16	16	14				
Resin C ^c	25	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.51	2.51	2.51	2.51	2.51	2.50	2.50	2.50	2.50	2.47	2.47	2.47	2.46				
		tan δ	8	10	13	27	34	31	29	29	29	29	29	29	39				
Rexolite 1422 ^d	25	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55*	2.54	2.54				
		tan δ	2.1	1.1	1	1.1	1.3	2	3.8	4.6*	4.6*	4.6*	4.6*	4.8	4.7				
Bureau of Standards Casting Resin ^e	25	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.64	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.60	2.59					
Vibron 140 ^f	25	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.59	2.59	2.59	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.57				
		tan δ	4	5	8	12	16	19	20	20	20	20	20	20	19	17.5			
Vibron 141 ^f	23	$\frac{\epsilon' / \epsilon_0}{T^{\circ}C}$	2.64	2.64	2.63	2.63	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62
		tan δ	6	7	11	19	33	39	34	34	34	34	34	34	34	28	28	28	28

a. Cross-linked polystyrene (Dow). b. Goodyear. c. Esso C oil in styrene-divinylbenzene solution (Polarcid). d. Rex Corp. e. 32.5% polystyrene, 53.5% poly-2,5-dichlorostyrene, 13% hydrogenated terphenoil, 0.5% divinylbenzene (U.S. Bur. Stand.). f. U. S. Rubber.

*Freq. = 1×10^9 .

I. Solids B. Organic 3. Plastics J. Polyvinyl resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

		$\frac{1x10^2}{T^{\circ}C}$	$\frac{1x10^3}{\epsilon' / \epsilon_0}$	$\frac{1x10^4}{\epsilon' / \epsilon_0}$	$\frac{1x10^5}{\epsilon' / \epsilon_0}$	$\frac{1x10^6}{\epsilon' / \epsilon_0}$	$\frac{1x10^7}{\epsilon' / \epsilon_0}$	$\frac{1x10^8}{\epsilon' / \epsilon_0}$	$\frac{1x10^9}{\epsilon' / \epsilon_0}$	$\frac{1x10^{10}}{\epsilon' / \epsilon_0}$	$\frac{1x10^{10}}{2.5x10^9}$
14) Polystyrene plus fillers											
Polystyrene 91%, carbon 9%	26	ϵ' / ϵ_0	3.85	3.85	3.85	3.85	3.84	3.81	3.60	3.46	
	tan δ		17	24	30	33	32	37	310	386	344
Polystyrene 70%, carbon 30%	25	ϵ' / ϵ_0	-----	-----	-----	-----	-----	-----	2300*	2500	1100
	tan δ		-----	-----	-----	-----	-----	-----	25.9*	20.8	19.4
Polystyrene 50%, carbon 50% ^a (molded at 1000 p.s.i.) ^b	25	ϵ' / ϵ_0	-----	-----	-----	-----	-----	-----	7300*	5600	2800
	tan δ		-----	-----	-----	-----	-----	-----	4600*	6200	3000
Lustrex Loaded Glass Mat ^b (field ⊥ plane of laminate)	25	ϵ' / ϵ_0	3.04	3.04	3.02	3.00	2.97	2.97	2.96		
	tan δ		13.8	8.8	7.4	7	8.3	10.6	13.8		
(field in plane of laminate)	25	ϵ' / ϵ_0	-----	-----	-----	-----	-----	-----	-----	3.07	3.07
	tan δ		-----	-----	-----	-----	-----	-----	-----	31	36
Polyglas P ^c (experimental)	24	ϵ' / ϵ_0	3.36	3.36	3.36	3.36	3.36	3.36	3.35	3.33	3.32
	tan δ		8	7	7	7	7	7	7	8.4	14.0
	ϵ' / ϵ_0	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.35	3.33	
	tan δ		30	17	12	9	8	7	-----	14	19
Polyglas P ^d (technical)	25	ϵ' / ϵ_0	3.38	3.38	3.38	3.38	3.38	3.38	3.36	3.35	3.34
	tan δ		9	9	9	9	9	9	9.6	11.7	19
15) Polychlorostyrenes											
Plastic CT-8 ^e	24	ϵ' / ϵ_0	2.61	2.61	2.60	2.60	2.60	2.6	2.60	2.60	2.59
	tan δ		< 2	< 2	< 2	< 2	< 2	2	2.5	3.1	29
	ϵ' / ϵ_0	2.61	2.61	2.61	2.60	2.60	2.60	2.6	2.6	2.60	
Plastic CQ-10D ^f	25	ϵ' / ϵ_0	2.70	2.70	2.70	2.70	2.70	2.70	2.69	2.67	2.66
	tan δ		5	5	5	6	8	10	11	11	10.8
	ϵ' / ϵ_0	2.66	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	
	tan δ		33	17	8	6	7	11	16	17	17

a. Cabot's #9 (Lab. Ins. Res.). b. 30% fiberglass (Monsanto). c. 18.6% Dow's C-244 polystyrene, 81.1% Corning's 790 glass powder, 0.25% paraffin, 0.1% Dow Corning's Ignition Sealing Compound No. 4 (Lab. Ins. Res.). d. Id. except that Monsanto's polystyrene was used (Monsanto). e. 97% poly-2,5-dichlorostyrene (Mathieson). f. copolymer of 50% 2,4,-25% 2,5-, 25% 2,3-, 2,6- and 3,4-dichlorostyrenes (Mathieson).

*Freq. = $1x10^9$.

I. Solids B. Organic 3. Plastics 1. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

15) Polychlorostyrene		$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{-2}}{25}$	$\frac{1 \times 10^{-3}}{2.94}$	$\frac{1 \times 10^{-4}}{2.91}$	$\frac{1 \times 10^{-5}}{2.88}$	$\frac{1 \times 10^{-6}}{2.85}$	$\frac{1 \times 10^{-7}}{2.80}$	$\frac{1 \times 10^{-8}}{2.77}$	$\frac{3 \times 10^{-9}}{2.72}$	$\frac{1 \times 10^{-10}}{2.70}$	$\frac{1 \times 10^{-11}}{2.70}$
Poly-3, 4-dichloro-styrene^a	82	ϵ' / ϵ_0	85	70	57	50	42	35	27	----	20	20
	103	ϵ' / ϵ_0	3.0	2.90	2.85	2.83	2.78	2.73	2.68	----	2.65	2.65
Exp. Plastic Q-409^b	90	ϵ' / ϵ_0	203	157	115	77	63	60	55	----	32	32
	79	ϵ' / ϵ_0	3.08	2.92	2.85	2.81	2.8	2.8	2.75	----	2.7	2.7
Polyglas D^c(experimental)	24	ϵ' / ϵ_0	355	275	200	120	82	78	70	----	60	60
	24	ϵ' / ϵ_0	6.0	4.9	3.7	3.3	----	----	----	60	60	60
Polyglas D^d(technical)	24	ϵ' / ϵ_0	850	1700	1400	750	----	----	----	2.60	2.60	2.60
	24	ϵ' / ϵ_0	2.60	2.60	2.60	2.60	2.60	2.60	2.60	----	2.60	2.60
16) Poly-2,5-dichloro-styrene plus fillers		$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	$\frac{26}{(58.1\%)} \text{, TiO}_2 \text{ (41.9\%)e}$	$\frac{14}{10.2}$	$\frac{8}{10.2}$	$\frac{5}{10.2}$	$\frac{3}{10.2}$	$\frac{3}{10.2}$	$\frac{3}{10.2}$	----	6	8.5
		$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	$\frac{16}{(34.7\%)} \text{, TiO}_2 \text{ (65.3\%)e}$	$\frac{6}{6}$	$\frac{4}{4}$	$\frac{3}{3}$	$\frac{3}{3}$	$\frac{3}{3}$	$\frac{3}{3}$	----	10.2	10.2
		$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	$\frac{41}{(18.6\%)} \text{, TiO}_2 \text{ (81.4\%)e}$	$\frac{30}{60}$	$\frac{20}{41}$	$\frac{12}{30}$	$\frac{9}{20}$	$\frac{8}{12}$	$\frac{8}{7}$	----	7.5	13
		$\frac{\text{tan } \delta}{\epsilon' / \epsilon_0}$	23	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30

a. ca. 95% (Monsanto). b. Copolymer of o- and p-chlorostyrenes (Dow). c. 34.9% Monsanto's poly-2,5-dichlorostyrene; 64.9% Corning's 790 glass powder, 0.1% paraffin wax, 0.1% Dow Corning's Ignition Sealing Compound No. 4 (Lab. Ins. Res.). d. Id. (Monsanto).

e. Monsanto's Styramic HT; Titanium Alloy's Tan Ticon T, heavy grade (Lab. Ins. Res.).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cent.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

		<u>$1x10^2$</u>	<u>$1x10^3$</u>	<u>$1x10^4$</u>	<u>$1x10^5$</u>	<u>$1x10^6$</u>	<u>$1x10^7$</u>	<u>$1x10^8$</u>	<u>$3x10^9$</u>	<u>$1x10^{10}$</u>
16) Poly-2,5-dichlorostyrene	plus fillers (cont.) <u>T_C</u>	ϵ'/ϵ_0	6.10	6.10	6.09	6.09	6.08	6.05	6.01	5.91
Poly-2,5-dichlorostyrene	23 (38.2%), MgTiO ₃ (61.8%) ^a	tan δ	35	22	14	10	7	6	7	8.9
Poly-2,5-dichlorostyrene	25 (63.0%), SrTiO ₃ (37.0%) ^b	ϵ'/ϵ_0	5.20	5.20	5.19	5.18	5.17	5.15	-----	4.97 4.90
Poly-2,5-dichlorostyrene	24 (40.5%), SrTiO ₃ (59.5%) ^b	tan δ	20	10	6	4	3	4	5	-----
Poly-2,5-dichlorostyrene	23 (25.2%), SrTiO ₃ (74.8%) ^b	ϵ'/ϵ_0	9.65	9.65	9.63	9.62	9.61	9.60	9.57	-----
Poly-2,5-dichlorostyrene	23 (14.4%), SrTiO ₃ (80.6%) ^b	tan δ	41	37	16	12	10	9	10	-----
Poly-2,5-dichlorostyrene	23 (66.6%), BaTiO ₃ (33.4%) ^c	ϵ'/ϵ_0	22.0	130	78	42	30	22	23	-----
Poly-2,5-dichlorostyrene	25 (32.8%), BaTiO ₃ (67.2%) ^c	ϵ'/ϵ_0	24.5	22.8	21.6	21.2	21.0	20.8	-----	19.5
Poly-2,5-dichlorostyrene	23 (23.5%), BaTiO ₃ (75.5%) ^c	tan δ	780	380	180	100	60	40	33	-----
Poly-2,5-dichlorostyrene	23 (21.0%), BaTiO ₃ (79.0%) ^c	ϵ'/ϵ_0	4.10	4.08	4.07	4.06	4.04	4.03	4.03	4.02 4.02
		tan δ	24	14	8	6	4	3	3	-----
		ϵ'/ϵ_0	9.7	9.7	9.7	9.7	9.7	9.7	9.7	-----
		tan δ	60	42	25	14	7	6	6	-----
		ϵ'/ϵ_0	15.8	15.8	15.8	15.8	15.7	15.7	15.7	-----
		tan δ	30	30	25	12	7	7	13	-----
		ϵ'/ϵ_0	19.4	19.3	19.1	18.9	18.9	18.9	18.9	-----
		tan δ	52	35	25	16	11	7	8	-----
		μ'/μ_0	-----	-----	-----	-----	-----	-----	-----	1.02 .98
		tan δ_m	-----	-----	-----	-----	-----	-----	-----	250 270
		ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	2.78 2.78
		tan δ_d	-----	-----	-----	-----	-----	-----	7 15	-----
		μ'/μ_0	-----	-----	-----	-----	-----	-----	1.04	-----
		tan δ_m	-----	-----	-----	-----	-----	-----	300	-----
		ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	2.7	-----
		tan δ_d	-----	-----	-----	-----	-----	-----	40	-----

a. Monsanto's Styramic HT; Titanium Alloy's Tam Ticon MC (Lab. Ins. Res.). b. Monsanto's Styramic HT; Titanium Alloy's Tam Ticon S (Lab. Ins. Res.). c. Monsanto's Styramic HT; Titanium Alloy's Tam Ticon B (Lab. Ins. Res.). d. Monsanto's D-1795; Plastic Metals' Plast-Iron, minus 20 mesh, annealed (Lab. Ins. Res.).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10⁴; frequency given in c/s.

	<u>1x10²</u>	<u>1x10³</u>	<u>1x10⁴</u>	<u>1x10⁵</u>	<u>1x10⁶</u>	<u>1x10⁷</u>	<u>1x10⁸</u>	<u>3x10⁹</u>	<u>1x10¹⁰</u>
16) Poly-2,5-dichlorostyrene plus fillers (cont.) T _C									
Poly-2,5-dichlorostyrene 25 (60%), Fe (40%) ^a	ϵ'/ϵ_0	---	---	---	---	---	---	---	5.2
	μ'/μ_0	---	---	---	---	---	---	1.16	.96
	$\tan \delta_d$	---	---	---	---	---	---	270	190
	$\tan \delta_m$	---	---	---	---	---	---	2300	2620
85	ϵ'/ϵ_0	---	---	---	---	---	---	5.1	
	μ'/μ_0	---	---	---	---	---	---	1.27	
	$\tan \delta_d$	---	---	---	---	---	---	---	
	$\tan \delta_m$	---	---	---	---	---	---	3000	
Poly-2,5-dichlorostyrene 25 (49.3%), Fe (50.7%) ^a	ϵ'/ϵ_0	9.8	9.7	9.5	9.2	9.0	8.7	8.08	6.93
	μ'/μ_0	---	3.00	---	---	2.70	---	2.00	1.24
	$\tan \delta_d$	110	130	160	190	220	320	601	644
	$\tan \delta_m$	---	---	---	---	340	---	2254	3170
Poly-2,5-dichlorostyrene 25 (40.7%) Fe (59.3%) ^a	ϵ'/ϵ_0	---	---	---	---	---	---	13.8	10
	μ'/μ_0	---	---	---	---	---	---	2.6	1.37
	$\tan \delta_d$	---	---	---	---	---	---	1950	1400
	$\tan \delta_m$	---	---	---	---	---	---	2810	4500
Poly-2,5-dichlorostyrene 25 (92%), Fe ₃ O ₄ (8%) ^b	ϵ'/ϵ_0	---	---	---	---	---	2.78	2.76	2.64
	μ'/μ_0	---	---	---	---	---	1.05	1.03	1.03
	$\tan \delta_d$	---	---	---	---	---	13	13	
	$\tan \delta_m$	---	---	---	---	---	77	200	420
Poly-2,5-dichlorostyrene 25 (83.7%) Fe ₃ O ₄ (16.3%) ^b	ϵ'/ϵ_0	---	---	---	---	---	3.2	3.2	3.2
	μ'/μ_0	---	---	---	---	---	1.12	1.07	.99
	$\tan \delta_d$	---	---	---	---	---	18	18	
	$\tan \delta_m$	---	---	---	---	---	200	420	580
Poly-2,5-dichlorostyrene (75%) Fe ₃ O ₄ (25%) ^b	ϵ'/ϵ_0	---	---	---	---	---	3.45	3.44	
	μ'/μ_0	---	---	---	---	---	1.19	1.12	
	$\tan \delta_d$	---	---	---	---	---	26	26	
	$\tan \delta_m$	---	---	---	---	---	250	590	

a. Monsanto's D-1795; Plastic Metals' Plast-Iron, minus 200 mesh, annealed (Lab. Ins. Ref.). b. Monsanto's D-1795; Mallinckrodt's magnetite (Lab. Ins. Ref.).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	<u>ϵ'/ϵ_0</u>	<u>1×10^2</u>	<u>1×10^3</u>	<u>1×10^4</u>	<u>1×10^5</u>	<u>1×10^6</u>	<u>1×10^7</u>	<u>1×10^8</u>	<u>3×10^9</u>	<u>1×10^{10}</u>
16) Poly-2,5-dichlorostyrene plus fillers (cont.) T_C	μ'/μ_0	----	----	----	----	----	----	----	4.08	4.07
Poly-2,5-dichlorostyrene 25 (55.9%) Fe_3O_4 (34.1%) ^a	μ'/μ_0	----	----	----	----	----	----	1.30	1.17	
	$\tan \delta_d$	----	----	----	----	----	----	42		
	$\tan \delta_m$	----	----	----	----	----	----	390	1010	
Poly-2,5-dichlorostyrene 25 (56.2%) Fe_3O_4 (43.8%) ^a	μ'/μ_0	----	----	----	----	----	----	5.00	4.98	
	$\tan \delta_d$	----	----	----	----	----	----	1.45	1.23	
	$\tan \delta_m$	----	----	----	----	----	75			
Poly-2,5-dichlorostyrene 25 (46.0%) Fe_3O_4 (54.0%) ^a	μ'/μ_0	----	----	----	----	----	560	1720		
	$\tan \delta_d$	----	----	----	----	----	7.4	7.3	7.3	
	$\tan \delta_m$	----	----	----	----	----	1.65	1.32	.91	
Poly-2,5-dichlorostyrene 25 (35.7%) Fe_3O_4 (64.3%) ^a	μ'/μ_0	----	----	----	----	----	150			
	$\tan \delta_d$	----	----	----	----	----	780	2400	3500	
	$\tan \delta_m$	----	----	----	----	----	9.8	9.5		
Poly-2,5-dichlorostyrene 25 (24.5%) Fe_3O_4 (75.5%) ^a	μ'/μ_0	----	----	----	----	----	1.94	1.41		
	$\tan \delta_d$	----	----	----	----	----	450	180		
	$\tan \delta_m$	----	----	----	----	----	980	3000		
Poly-2,5-dichlorostyrene 25 (38.55%) (Mn, Fe_3O_4) ^b (61.45%) ^b	μ'/μ_0	----	----	----	----	----	20	18		
	$\tan \delta_d$	----	----	----	----	----	2.38	1.60		
	$\tan \delta_m$	----	----	----	----	----	2600	300		
Poly-2,5-dichlorostyrene 25 (21.3%) (Mn, Fe_3O_4) ^b (78.7%) ^b	μ'/μ_0	----	----	----	----	----	1430	3700		
	$\tan \delta_d$	2500	2400	2300	1900	900				
	$\tan \delta_m$	----	----	----	----	----	4000			
	ϵ'/ϵ_0	99	39	29	21	7.4		6.9	6.5	
	μ'/μ_0	----	----	----	----	----		4.3	1.32	
	$\tan \delta_d$	27700	10000	6200	4800	930		90	< 50	
	$\tan \delta_m$	----	----	----	----	----		4900	13200	

a. Monsanto's D-1795; Mallinckrodt's magnetite (Lab. Ins. Res.). b. Monsanto's D-1795; iron-manganese oxide (Lab. Ins. Res.).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10⁴; frequency given in c/s.

	<u>T_g</u> <u>cyclohexane</u>	<u>T_g</u> <u>cyclohexane</u>	<u>ε'/ε₀</u>	<u>1x10²</u>	<u>1x10³</u>	<u>1x10⁴</u>	<u>1x10⁵</u>	<u>1x10⁶</u>	<u>1x10⁷</u>	<u>1x10⁸</u>	<u>3x10⁸</u>	<u>3x10⁹</u>	<u>1x10¹⁰</u>
17) <u>Polyvinyl</u> <u>cyclohexane</u>	24	24	<u>ε'/ε₀</u>	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Polyvinylcyclohexane ^a			tan δ	15	2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
18) <u>Poly-α-vinylnaphthalene</u> <u>Poly-α-vinylnaphthalene^b</u>	24	24	<u>ε'/ε₀</u>	----	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
			tan δ	----	9.5	6.7	7.5	8.7	13	22	22	22	22
19) <u>Poly-2-vinylpyridine</u> <u>Poly-2-vinylpyridine^b</u>	22	22	<u>ε'/ε₀</u>	4.91	4.64	4.26	3.77	3.56	3.33	3.1	3.06	2.98	2.98
			tan δ	6	360	460	560	660	560	420	280	240	135
2-Vinylpyridine-styrene copolymer ^b	23	23	<u>ε'/ε₀</u>	3.44	3.38	3.26	3.13	3.00	2.90	2.82	----	2.76	2.76
			tan δ	6	168	230	270	290	260	185	120	----	65
20) <u>Poly-N-vinylcarbazole</u> <u>Polelectron #24^c</u>	25	25	<u>ε'/ε₀</u>	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.88
			tan δ	6	13	9	6	5	4	5	6	6	9.3
	80	80	<u>ε'/ε₀</u>	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.88
			tan δ	6	19	10	8	9	9	9	9	9	9.3
k. Polyesters													
Laminate 4115 ^d	25	<u>ε'/ε₀</u>	3.24	3.22	3.20	3.17	3.12	3.07	2.94	2.87*	2.83	2.82	2.82
		tan δ	6	37.5	43.2	68.3	113	135	147	141	107*	93	88
Experimental Resin FDU-7-669 ^d	25	<u>ε'/ε₀</u>	4.15	4.05	3.93	3.77	3.58	3.44	3.20	----	3.00	2.95	2.95
Laminate PDI7-627 ^d	25	<u>ε'/ε₀</u>	3.26	3.25	3.23	3.18	3.08	3.06	3.03	2.96*	2.92	2.86	2.86
Laminate PDI7-650 ^d	25	<u>ε'/ε₀</u>	3.02	3.00	2.98	2.95	2.89	2.82	2.78	----	155	142	142
Laminate 4-205 ^d	25	<u>ε'/ε₀</u>	4.45	4.36	4.24	4.03	3.86	3.69	3.49	107*	95	91.4	91.4
		tan δ	6	147	162	219	301	360	345	340	----	2.74	2.72
Formica Z65 ^e (field II laminate)	25	<u>ε'/ε₀</u>	5.21	5.10	5.00	4.89	4.70	4.35	----	3.63*	3.69	3.49	3.49
(field I laminate)	25	<u>ε'/ε₀</u>	4.77	4.70	4.68	4.60	4.15	4.17	----	4.85*	4.45	4.25	4.25
		tan δ	6	125	108	131	185	302	418	418	418	418	418

a. Hydrogenated polystyrene (Dow). b. Lab. Ins. Res. c. Poly-N-vinylcarbazole, 1.3% HB-40 oil (Gen. Aniline). d. Amer. Cyanamid.

e. 50% Shell's DAP 85/80, 50% paper (Formica).

*Freq. = 1x10⁹.

I. Solids B. Organic J. Plastics (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

k. Polyesters (cont.)	$\frac{T_g}{^{\circ}C}$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{1x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$
Formica Z80 ^a	25	ϵ'/ϵ_0	4.76	4.75	4.72	4.65	4.46	4.08	3.77	3.53*
(Field II laminate)		tan δ	175	160	210	310	420	565	500	390*
(Field I laminate)	25	ϵ'/ϵ_0	4.52	4.42	4.38	4.33	4.15	3.91		310
Glastic S ^b	26	ϵ'/ϵ_0	3.50	3.39	3.29	3.22	3.16	3.14	3.07	250
Glastic M ^b		tan δ	330	250	160	98	190	105	130	
Plaskon 911 ^c	24	ϵ'/ϵ_0	3.88	3.82	3.76	3.72	3.65	3.57	3.53	
		tan δ	270	185	135	125	130	130	135	
	80	ϵ'/ϵ_0	4.27	4.17	4.06	3.95	3.83	3.70	3.55	---
		tan δ	165	150	155	200	270	320	340	299
Marco Resin MR-21C ^d	25	ϵ'/ϵ_0	3.37	3.35	3.31	3.25	3.16	3.08	---	2.84
		tan δ	53	51	65	102	150	170	---	2.90
Marco Resin MR-23C ^d	25	ϵ'/ϵ_0	4.56	4.50	4.40	4.28	4.14	3.88	---	3.24
		tan δ	130	140	170	220	340	570	---	810
Marco Resin MR-25G ^d	25	ϵ'/ϵ_0	3.27	3.24	3.20	3.15	3.10	3.06	2.90	2.86
Laminating Resin MP, Glass reinforced ^e	25	ϵ'/ϵ_0	----	----	----	----	----	----	----	149
Laminating Resin MT, Glass reinforced ^f	25	ϵ'/ϵ_0	----	----	----	----	----	----	----	106
Laminate BD-44 ^g	24	ϵ'/ϵ_0	3.32	3.28	3.22	3.19	3.14	3.08	3.02	2.99
		tan δ	95	81	85	105	125	140	150	132

a. 52% Shell's DAP 25/50, 48% yarn fabric (Formica). b. With Fiberglas (Laminated Plastics). c. Unsaturated polyester (Libby-Owens-Ford). d. Unsaturated polyester (Marco). e. Resin of 50% Vibron x-1039 alkyd and 50% triallyl cyanurate plus catalyst and Fiberglas ECC-181-114 (Naugatuck). f. Resin of 45% polyethylene tetraclophthalate-maleate alkyd and 55% triallyl cyanurate plus catalyst and Fiberglas ECC-181-114 (Naugatuck). g. Selectron 5003, Fiberglas (Owens-Corning).

*Freq. = $1x10^9$.

I. Solids B. Organic 3. Plastics (cont.)

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

		$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^8}{\epsilon'/\epsilon_0}$	$\frac{1x10^9}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$	$\frac{2.5x10^{10}}{\epsilon'/\epsilon_0}$
K. Polyesters (cont.)	$T^\circ C$												
Laminite BK 164 ^a	24	ϵ'/ϵ_0	4.12	4.10	4.09	4.07	4.05	4.03	4.00	3.98	3.94	3.90	
		tan δ	67	58	63	80	96	110	112	108	120	130	
Styrol 16B ^b	25	ϵ'/ϵ_0	----	----	----	----	----	----	----	----	----	2.88	
		tan δ	----	----	----	----	----	----	----	----	----	180	
Styrol 16C ^b	25	ϵ'/ϵ_0	----	----	----	----	----	----	----	----	----	2.75	
		tan δ	----	----	----	----	----	----	----	----	----	160	
Styrol 16D ^b	25	ϵ'/ϵ_0	----	----	----	----	----	----	----	----	----	2.81	
		tan δ	----	----	----	----	----	----	----	----	----	140	
Paraplex P13 ^c	25	ϵ'/ϵ_0	4.02	4.00	3.92	3.92	3.65	3.32	3.08	2.89*	2.77	2.77	
		tan δ	73	108	184	310	530	590	600	440*	320	290	
Paraplex P43 ^c	25	ϵ'/ϵ_0	3.23	3.22	3.29	3.16	3.11	3.04	2.98	2.89*	2.85	2.85	
Polydiallyl phthalate ^d	26.8	ϵ'/ϵ_0	3.60	3.57	3.50	3.42	3.35	3.24	3.1	----	2.95	2.95	
		tan δ	33	43	68	98	130	160	160	110*	100	80	
Allymer CR-39 ^e	24	ϵ'/ϵ_0	4.18	4.14	4.03	3.85	3.52	3.27	3.07	2.88	2.76	2.76	
		tan δ	104	95	118	150	200	241	195	118	118	118	
		tan δ	90	120	210	380	520	460	330	203	203	165	
Allymer CR-39 laminate ^f	84	ϵ'/ϵ_0	4.90	4.84	4.70	4.47	4.18	3.85	3.45	3.02	2.88	2.76	
		tan δ	130	140	170	250	440	840	740	370	370	370	
Phoresin ^g	25	ϵ'/ϵ_0	3.98	3.84	3.70	3.65	3.49	3.32	3.15	3.10	3.03	3.02	2.96
		tan δ	260	270	320	330	280	210	165	145	171	165	164
<u>m. Alkyd resins</u>													
Chlorinated alkyd diisocyanate, foamed ^h	25	ϵ'/ϵ_0	----	----	----	----	----	----	----	----	----	1.179	
Alkyd, diisocyanate, foamed ^k	25	ϵ'/ϵ_0	1.223	1.223	1.223	1.223	1.218	1.205	1.20	1.20	1.20	1.19	
Red Glyptal #2201 ^m	25	ϵ'/ϵ_0	4.9	4.5	4.1	4.0	3.9	3.8	3.8	3.4	3.4	2.2	
		tan δ	760	600	500	400	320	290	290	290	290	290	

a. 38% polyester (Bakelite BR3-16631), 62% Fiberglas (Owens-Corning). b. Robertson. c. Rohm and Haas. d. Shell Dev. e. Allyl resin (Southern Alkali Corp.). f. 40% resin, 60% ECC-11-148 Fiberglas (Southern Alkali Corp.). g. Diallyl phenyl phosphonate resin (Victor). h. Cornell Aeronautical Labs. k. Goodyear Aircraft. m. General Electric.

*Frequency = $1x10^9$.

I. Solids B. Organic 3. Plastics (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

m. Alkyd resins	$\frac{T^{\circ}C}{(cont.)}$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$
#51 Permo Potting Compound ^a	25	ϵ'/ϵ_0	3.18	2.95	2.83	2.74	2.70	2.64	2.59	2.53
Glastic Grade GF ^b	25	ϵ'/ϵ_0	tan δ	410	260	174	124	101	120	125
Glastic Grade MM ^b	25	ϵ'/ϵ_0	4.17	4.13	4.09	4.02	3.96	3.88	3.78	122
Glastic Grade MP ^b	25	ϵ'/ϵ_0	tan δ	102	87	84	99	115	125	136
Glastic Grade A-2 ^b	25	ϵ'/ϵ_0	tan δ	---	---	---	3.56	267	267	267
Plaskon Alkyd Special Electrical Granular ^c	25	ϵ'/ϵ_0	tan δ	5.32	5.10	4.96	4.90	4.76	4.65	4.55
Plaskon Alkyd 411 ^c	25	ϵ'/ϵ_0	tan δ	366	236	170	147	149	152	138
Plaskon Alkyd 420 ^c	25	ϵ'/ϵ_0	tan δ	6.02	5.77	5.60	5.36	5.19	4.95	4.63
Plaskon Alkyd 422 ^c	25	ϵ'/ϵ_0	tan δ	340	240	220	260	310	320	288
Plaskon Alkyd 440 ^c	25	ϵ'/ϵ_0	tan δ	5.50	5.35	5.24	5.10	5.03	4.90	4.82
Plaskon Alkyd 440A ^c	25	ϵ'/ϵ_0	tan δ	270	160	130	147	153	147	145
Plaskon Alkyd 442 ^c	25	ϵ'/ϵ_0	tan δ	5.47	5.26	5.14	5.01	4.92	4.85	4.77
Plaskon Alkyd 440 ^c	25	ϵ'/ϵ_0	tan δ	365	213	151	134	120	113	110
Plaskon Alkyd 440A ^c	25	ϵ'/ϵ_0	tan δ	191	151	154	185	196	188	172
Plaskon Alkyd 442 ^c	25	ϵ'/ϵ_0	tan δ	165	133	131	143	146	134	124*
n. Epoxy resins										
Araldite Casting Resin Type B ^d	25	ϵ'/ϵ_0	tan δ	17	24	50	110	190	270	340
Araldite E-134 ^d	25	ϵ'/ϵ_0	tan δ	7.3	6.1	5.3	4.7	4.4	4.1	3.7
Araldite Casting Resin G ^d	25	ϵ'/ϵ_0	tan δ	105	104	141	210	270	288	300

a. Hardman. b. Laminated Plastics. c. Litbey-Owens-Ford. d. Ciba.

c. Litbey-Owens-Ford. d. Ciba.

I. Solids B. organic 3. Plastics (cont.)

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

n. Epoxy Resins (cat.)	η°_0	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^{10}}{\epsilon' / \epsilon_0}$
Araldit Adhesive	25	ϵ' / ϵ_0	4.00	3.97	3.91	3.82	3.71	3.46	3.27	3.14	3.14
Type I Natural ^a		$\tan \delta$	29	52	120	200	300	350	340	---	230
Araldite Adhesive	25	ϵ' / ϵ_0	11.6	11.5	11.3	11.0	10.5	10.2	9.9	9.6	9.2
Type I Silver ^a		$\tan \delta$	38	62	120	190	300	370	360	520	980
Hysol 6600 ^b	25	ϵ' / ϵ_0	3.47	3.43	3.38	3.30	3.26	3.17	3.10	3.07	3.00
		$\tan \delta$	73	61	70	92	130	170	170	120	120
Hysol 6020 ^b	25	ϵ' / ϵ_0	3.96	3.90	3.82	3.67	3.54	3.42	3.29	3.01	2.99
		$\tan \delta$	68	113	206	260	272	266	299	274	252
Hysol 6130 flexible Potting Compound ^b	25	ϵ' / ϵ_0	6.65	6.15	5.75	5.37	4.74	4.15	3.61	3.20	3.11
		$\tan \delta$	605	485	469	593	840	1010	900	380	324
Hysol 6000 FR ^b	25	ϵ' / ϵ_0	3.85	3.80	3.69	3.64	3.57	3.44	3.33	3.18	3.18
		$\tan \delta$	90	99	107	163	227	248	250	192	180
Hy-tuf <u>semifluid Grade</u> GPI181 ^b (Field I laminate) (Field II laminate)	25	ϵ' / ϵ_0	4.67	4.62	4.52	4.45	4.34	4.21	4.15	4.08	4.05
		$\tan \delta$	92	99	125	145	212	239	242	177	180
Epon Resin 46 ^c	25	ϵ' / ϵ_0	----	----	----	----	----	----	4.14*	4.08	4.05
		$\tan \delta$	31	38	68	111	142	191	264	220*	210
<u>o. Miscellaneous Plastics</u>											
E Resin ^d	23	ϵ' / ϵ_0	2.49	2.49	2.48	2.47	2.45	2.45	2.43	2.42	2.42
		$\tan \delta$	7	4	< 3	< 5	5	8	8	6	5
	80	ϵ' / ϵ_0	2.5	2.5	2.5	2.5	2.45	2.45	2.45	2.4	2.4
		$\tan \delta$	25	14	8	5	4	6	7	15	17
Same material after 3 1/2 yrs. at room temp. and humidity	25	ϵ' / ϵ_0	2.56	2.56	2.55	2.54	2.54	2.53	2.5	2.44	2.43
		$\tan \delta$	8	11	16	19	21	22	19	16	11
Pernafil 3256 ^e	24	ϵ' / ϵ_0	4.27	4.22	4.12	4.01	3.86	3.70	3.5	3.1	3.0
		$\tan \delta$	98	120	170	230	300	330	340	276	290
	99	ϵ' / ϵ_0	4.95	4.85	4.75	4.61	4.48	4.28	4.05	3.34	3.34
		$\tan \delta$	200	155	160	200	300	440	570	580	580
	125	ϵ' / ϵ_0	5.12	5.04	4.92	4.77	4.62	4.4	4.1	3.38	3.38
		$\tan \delta$	280	180	170	185	260	410	550	560	560
Piccopale Resin ^f	25	ϵ' / ϵ_0	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.30	2.30
		$\tan \delta$	< 3	< 3	< 3	< 3	< 5	2	8	3.5	3.5

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^a. Ciba. ^b. Houghton Labs. ^c. Shell Chem. ^d. Cross-linked addition hydrocarbon polymer (Epoxy Lab.). ^e. Linear addition hydrocarbon copolymer made with aliphatic dienes and olefins (Penn. Industrial Chem.). ^f Freq. = 1×10^9 .

I. Solids, B. Organic & Inorganics

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	$T^{\circ}C$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{1x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$
a. Natural Rubber										
Hevea rubber ^a	-12	ϵ'/ϵ_0	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
		$\tan \delta$	10	14	24	44	55	38	33	
	25	ϵ'/ϵ_0	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
		$\tan \delta$	28	18	14	14	18	32	50	---
	80	ϵ'/ϵ_0	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
		$\tan \delta$	132	79	48	27	21	21	30	
Hevea rubber, vulcanized ^b	27	ϵ'/ϵ_0	2.94	2.94	2.93	2.88	2.74	2.52	2.42	2.36
		$\tan \delta$	48	24	62	220	446	410	180	---
Hevea rubber compound ^c	27	ϵ'/ϵ_0	4.09	4.01	3.92	3.80	3.64	3.44	3.3	47
		$\tan \delta$	130	155	182	230	308	405	265	
Hevea rubber compound ^d	27	ϵ'/ϵ_0	---	36	27	14	9.0	7.0	6.8	3.25
		$\tan \delta$	---	25000	12000	4000	2500	1600	850	148
Cellular Rubber ^e	25	ϵ'/ϵ_0	---	---	---	---	---	---	---	6.3
		$\tan \delta$	---	---	---	---	---	---	---	234
#49 Permo Potting Compound ^f	25	ϵ'/ϵ_0	3.46	3.39	3.28	3.18	2.96	2.80	2.72	2.63*
b. Gutta-percha ^g	25	ϵ'/ϵ_0	2.61	2.60	2.58	2.55	2.53	2.50	2.47	2.45
		$\tan \delta$	5	4	9	21	42	80	120	110
c. Balata										
Balata, precipitated ^h	25	ϵ'/ϵ_0	2.50	2.50	2.50	2.50	2.47	2.42	2.41	2.40
		$\tan \delta$	9	5	4	5	15	33	62	63
d. Cyclized Rubbers										
Pliolite ⁱ	27	ϵ'/ϵ_0	2.5	2.5	2.5	2.5	2.5	2.45	2.4	2.4
		$\tan \delta$	52	35	31	31	37	46	46	31
Pliolite GR ^j	25	ϵ'/ϵ_0	2.6	2.6	2.6	2.55	2.55	2.55	2.55	2.5
		$\tan \delta$	92	98	78	60	44	33	33	33

a. Pale crepe (Rubber Res. Corp.). b. 100 pts. pale crepe, 6 pts. sulfur (Rubber Res. Corp.). c. 100 pts. pale crepe, 1 pt. stearic acid, 10 pts. United Black, 5 pts. Kador, 0.5 pts. Captax, 3 pts. sulfur (Rubber Res. Corp.). d. 100 pts. pale crepe, 1 pt. stearic acid, 40 pts. United Black, 5 pts. Captax, 3 pts. sulfur (Rubber Res. Corp.). e. Cellular Rubber Prod. f. Depolymerized rubber (Hardman). g. Palauquin Oblongifolium (Hermann Weber). h. Minusops Globosa (Hermann Weber). i. Goodyear.
*req. = $1x10^9$.

I. Solids B. Organic 4. Elastomers (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

d. Cyclized Rubbers (cont.)	T_C	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\epsilon'/\epsilon_0}$
Platinum M-190-C ^a	24	ϵ'/ϵ_0	14	12	9.5	7.9	6.3	4.8	4.0	----
		$\tan \delta$	7800	1900	850	900	2000	1900	1000	----
e. Buna Rubbers										
Air seal ^b	24	ϵ'/ϵ_0	15.3	8.9	6.2	4.4	3.6	3.3	3.0	2.8
		$\tan \delta$	5200	3100	2300	1700	990	740	580	410
GR-S (Buna S) uncured ^c	-12	ϵ'/ϵ_0	----	2.5	2.5	2.5	2.5	2.45	2.45	3.76
		$\tan \delta$	----	13	24	62	80	50	38	740
GR-S (Buna S) compound ^d	26	ϵ'/ϵ_0	2.5	2.5	2.5	2.5	2.50	2.45	2.45	2.45
		$\tan \delta$	6	9	10	18	38	69	71	44
GR-S (Buna S) compound ^d	26	ϵ'/ϵ_0	2.66	2.66	2.66	2.65	2.56	2.52	2.52	2.49
		$\tan \delta$	7	9	25	60	120	160	95	56
GR-S (Buna S) compound ^d	25	ϵ'/ϵ_0	2.98	2.97	2.95	2.93	2.91	2.88	2.82	2.78
HIG-117-G ^e										2.77
		$\tan \delta$	10	24	54	100	120	128	80	57
		ϵ'/ϵ_0	2.84	2.83	2.82	2.81	2.78	2.76	2.72	2.69
Hycar OR Cell-tite ^f	25	ϵ'/ϵ_0	1.41	1.40	1.39	1.38	1.38	1.38	1.38	1.38
		$\tan \delta$	115	58	50	51	56	54	47	39
Marbon S, Buna S	25	ϵ'/ϵ_0	1.31	1.31	1.31	1.30	1.30	1.30	1.29	1.28
Hardboard ^g										1.27
f. Butyl Rubbers										
GR-I (butyl rubber) ^h	25	ϵ'/ϵ_0	2.39	2.38	2.37	2.36	2.35	2.35	2.35	2.35
		$\tan \delta$	34	35	27	13	10	10	10	9
GR-I compound ⁱ	25	ϵ'/ϵ_0	2.43	2.42	2.41	2.40	2.40	2.39	2.39	2.38
		$\tan \delta$	50	60	58	38	22	15	10	9.9

a. Solution and suspension of thermosetting resins and vulcanizable elastomers (Goodyear). b. Kearney. c. Copolymer of 75% butadiene and 25% styrene (Rubber Res. Corp.). d. 100 pts. GR-S, 1 pt. stearic acid, 5 pts. Eodor, 5 pts. Captax, 3 pts. Sulfur (Rubber Res. Corp.). e. Irfur, Selanac, Altax, Alcroflex, Heli ozone, Cumar MH, stearic acid, limestone, Marbon S-1, etc. (Gen. Cable). f. Based on butadiene polymer (Sponge Rubber Prod.). g. U.S.Rubber. h. Copolymer of 98-99% isobutylene, 1-2% isoprene (Rubber Res. Corp.). i. 100 pts. GR-I 44-7 M₂K, 5 pts. zinc oxide (from ZnCO₃), 1 pt. Tuads, 1.5 pts. sulfur (Rubber Res. Corp.).

I. Solids, B. Organic 4. Elastomers (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

d. Nitride Rubbers		$T^{\circ}C$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{1x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$
Kralastic BE Natural ^a	25	ϵ'/ϵ_0	4.80	4.75	4.70	4.40	4.00	3.30	3.00	2.85*	2.80
		tan δ	280	130	180	530	1100	1050	560	240*	180
Kralastic BM Natural ^a	25	ϵ'/ϵ_0	4.48	4.45	4.35	4.20	3.78	3.15	2.91	2.83*	2.76
		tan δ	130	96	160	490	990	940	490	220*	160
Kralastic D Natural ^a	25	ϵ'/ϵ_0	3.54	3.54	3.51	3.44	3.20	2.90	2.78	2.68*	2.66
		tan δ	105	52	82	260	530	550	270	130*	93
Kralastic EBMU Natural ^a	25	ϵ'/ϵ_0	4.47	4.42	4.36	4.29	4.05	3.38	2.98	2.88*	2.80
		tan δ	102	75	102	230	720	1300	760	300*	210
Kralastic F Natural ^a	25	ϵ'/ϵ_0	4.20	4.20	4.15	4.00	3.61	3.11	2.87	2.80*	2.70
		tan δ	140	65	120	440	940	860	460	190*	150
Royalite 149-11 ^b	25	ϵ'/ϵ_0	5.41	5.20	5.12	4.87	4.41	3.62	-----	3.18*	3.13
		tan δ	320	165	250	590	1080	900	-----	260*	200
Expanded Royalite M21982-1 ^b	25	ϵ'/ϵ_0	1.28	1.26	1.25	1.20	1.15	-----	-----	-----	-----
(field I plane of sample)			tan δ	175	108	150	240	184	-----	-----	-----
(field II plane of sample)	25	ϵ'/ϵ_0	---	---	---	---	---	---	---	1.18*	1.15
Expanded Royalite M22190 ^b	25	ϵ'/ϵ_0	1.23	1.22	1.19	1.16	1.14	-----	-----	54*	56
(field I plane of sample)			tan δ	157	111	141	162	143	-----	-----	36
(field II plane of sample)	25	ϵ'/ϵ_0	---	---	---	---	---	---	---	1.15*	1.15
		tan δ	---	---	---	---	---	---	40*	32	31

h. Neoprene^c

Neoprene GF ^c	26	ϵ'/ϵ_0	7.5	6.5	6.2	6.1	5.7	4.7	3.4	-----	2.84
		tan δ	6000	860	330	300	950	2000	1600	-----	480
Neoprene compound ^d	24	ϵ'/ϵ_0	6.70	6.50	5.54	6.47	6.26	5.54	4.5	4.24	4
		tan δ	160	110	115	150	380	1190	900	636	339
	80	ϵ'/ϵ_0	6.70	6.20	6.00	5.86	5.75	5.65	5.2	4.73	4.40
		tan δ	2700	430	140	92	93	320	900	1200	960

a. Naugatuck. b. Polystyrene-acrylonitrile and polybutadiene-acrylonitrile (U.S.Rubber). c. Poly-2-chlorobutadiene-1,3 stabilized with tetraethylthiuram disulfide (Du Pont). d. 38% GN, 28.4% Catalpo Clay, 14% blanc fixe, 0.4% Gaster (carbon black), 1.9% paraffin, 3.3% Circo (light process oil), 0.2% stearic acid, 0.8% Neozone A, 0.4% Parazone, 7.6% Litharge (DuPont).

*Freq. = $1x10^9$.

I. Solids B. Organic 4. Elastomers (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	$T^{\circ}\text{C}$	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$
1. Thiokol	23	ϵ' / ϵ_0	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	1×10^9
Thiokol, Type TA compound ^a	tan δ	----	2260	515	200	110	70	30	24	16
Thiokol PRI compound ^b	25	ϵ' / ϵ_0	----	12900	8000	5100	3900	3200	2800	2200
Thiokol ST compound ^c	25	ϵ' / ϵ_0	----	17900	15200	7550	740	106	----	20.5*
	tan δ	----	36300	56400	88000	40000	27000	----	2600*	17.1
	25	ϵ' / ϵ_0	----	17300	5100	600	215	90	----	2300
	tan δ	----	10000	17000	36000	18000	7600	----	3000*	2200
									3600	4000

J. Silicones Rubbers

Silastic 120 ^d	25	ϵ' / ϵ_0	5.78	5.76	5.75	5.75	5.75	5.75	5.74	5.73
Silastic 125 ^d	25	ϵ' / ϵ_0	7.1	7.1	7.0	7.0	6.9	6.9	6.8	----
Silastic 150 ^e	25	ϵ' / ϵ_0	5.87	5.85	5.79	5.61	5.39	5.09	5.0	5.0
Silastic 152 ^f	25	ϵ' / ϵ_0	2.96	2.95	2.95	2.95	2.95	2.95	2.95	2.95
Silastic 160 ^g	25	ϵ' / ϵ_0	5.8	5.2	4	3.5	5.4	10.4	20	59*
Silastic 167 ^h	25	ϵ' / ϵ_0	8.6	8.6	8.6	8.5	8.5	8.5	8.5	8
Silastic 180 ⁱ	25	ϵ' / ϵ_0	4.66	4.60	4.56	4.53	4.53	4.52	4.5	4.5
Silastic 181 ^j	25	ϵ' / ϵ_0	67	63	54	40	30	27	35	56
Silastic 250 ^k	25	ϵ' / ϵ_0	3.19	3.18	3.17	3.16	3.16	3.19	3.18	3.11
	tan δ	55	30	69	106	64	29	28	29	36

a. 100 pts. Thiokol (organic polysulfide), 10 pts. zinc oxide, 60 pts. semi-reinforcing carbon black, 1 pt. stearic acid, 0.5 pt. diphenylguanidine, 0.35 pt. Altax (Thiokol). b. 100 pts. polysulfide copolymer of bis (2-chloroethyl) formal and ethylene dichloride, 60 pts. carbon blacks, compounding ingredients. (Thiokol). c. 100 pts. polysulfide polymer of bis (2-chloroethyl) formal, 60 pts. carbon blacks, compounding ingredients. (Thiokol). d. 50% siloxane elastomer, 50% TiO_2 (Dow Corning). e. 35% siloxane elastomer, 35% ZnO , 30% CaCO_3 . (Dow Corning). f. Dow Corning. g. 33% siloxane elastomer, 33% ZnO , 33% TiO_2 (Dow Corning). h. 33% siloxane elastomer, 67% TiO_2 (Dow Corning). i. 35% siloxane elastomer, 35% SiO_2 , 30% TiO_2 (Dow Corning). j. 45% siloxane elastomer, 55% SiO_2 (Dow Corning). k. 70% siloxane elastomer, 30% SiO_2 (Dow Corning).

*Freq. = 1×10^9 .

I. Solids, B. Organic 4. Elastomers (cont.)

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	<u>J. Silicones Rubbers</u>	<u>T°C</u>	<u>ϵ'/ϵ_0</u>	<u>1×10^2</u>	<u>1×10^3</u>	<u>1×10^4</u>	<u>1×10^5</u>	<u>1×10^6</u>	<u>1×10^7</u>	<u>1×10^8</u>	<u>3×10^9</u>	<u>1×10^9</u>
(cont.)	Silastic X-4342 ^a	25	ϵ'/ϵ_0	3.22	3.18	3.16	3.14	3.12	3.11	3.08	3.08	3.00
			tan δ	51	64	60	48	29	20	23	35	83
Silastic 6167 ^b	25	ϵ'/ϵ_0	10.1	10.1	10.0	10	10	10	10	10	10	10
			tan δ	41	26	17	13	9.5	10	27	55	450
Silastic 6181 ^c	25	ϵ'/ϵ_0	3.66	3.53	3.42	3.35	3.31	3.30	3.27	3.25	3.23	3.20
			tan δ	200	250	190	100	57	34	32	36	88
Silastic X-6734 ^d	25	ϵ'/ϵ_0	3.21	3.12	3.12	3.12	3.10	3.08	3.08	3.08	3.01	3.00
			tan δ	28	19	31	53	37	23	29	44	144
Silastic 7181 ^e	25	ϵ'/ϵ_0	3.72	3.55	3.45	3.37	3.33	3.31	3.31	3.28	3.20	3.15
			tan δ	210	250	190	97	53	29	24	29	75
SE-1450 ^e	25	ϵ'/ϵ_0	3.09	3.08	3.08	3.08	3.07	3.06	3.05	3.03*	2.97	2.88
			tan δ	16	7.2	5.3	7	11	17	30	74*	158
SE-460 ^e	25	ϵ'/ϵ_0	3.14	3.12	3.11	3.10	3.10	3.09	3.07	3.05*	3.02	2.94
			tan δ	56	54	44	25	12	15	23	57*	98
SE-550 ^e	25	ϵ'/ϵ_0	3.14	3.12	3.10	3.10	3.10	3.08	3.06	3.02*	3.00	2.94
			tan δ	13	7.8	6.5	7	9.5	16	31	84*	143
SE-972 ^e	25	ϵ'/ϵ_0	3.40	3.35	3.25	3.22	3.20	3.18	3.16	3.15*	3.13	3.08
			tan δ	64	67	58	46	30	27	32	65*	97
<hr/>												
<u>5. Natural Resins</u>												
<u>Amber^f</u>												
	25	ϵ'/ϵ_0	2.7	2.7	2.7	2.7	2.65	2.65	-----	-----	2.6	2.6
		tan δ	12.5	18	31	43	56	68	-----	-----	82	90
	80	ϵ'/ϵ_0	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.65	2.60
Shellac, natural XI ^g	28	ϵ'/ϵ_0	3.86	3.81	3.75	3.66	3.47	3.26	3.10	-----	110	115
		tan δ	65	74	128	225	310	350	300	-----	-----	254
	70	ϵ'/ϵ_0	6.50	5.65	5.10	4.60	4.33	4.00	3.80	-----	3.45	732
		tan δ	1050	860	650	460	400	540	700	-----	-----	-----

a. 50% siloxane elastomer, 50% SiO₂ (Dow Corning). b. 33% siloxane elastomer, 67% TiO₂ (Dow Corning). c. 45% siloxane elastomer, 55% SiO₂ (Dow Corning). d. 70% siloxane elastomer, 30% SiO₂ (Dow Corning). e. General Electric. f. Fossil resin (Amber Mines).

g. Contains ca. 3.5% wax (Zinsser).

*Freq. = 1×10^9 .

I. Solids B. Organic (Cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

	π^o_C	$1x10^2$	$1x10^3$	$1x10^4$	$1x10^5$	$1x10^6$	$1x10^7$	$1x10^8$	$3x10^8$	$3x10^9$	$1x10^{10}$	$2.5x10^{10}$
5. Natural Resins (cont.)												
Shellac, natural	27	ϵ'/ϵ_0	3.84	3.82	3.75	3.66	3.50	3.30	3.1	-----	2.86	
Zinfo ^a		$\tan \delta$	58	64	132	250	313	341	345	-----	290	
Shellac, pure C	28	ϵ'/ϵ_0	3.99	3.92	3.84	3.69	3.50	3.32	3.2	-----	2.94	
garnet ^b		$\tan \delta$	137	102	131	205	304	347	340	-----	270	
Shellac, garnet dowized ^c	26	ϵ'/ϵ_0	3.60	3.56	3.48	3.40	3.30	3.20	3.05	-----	2.75	
Chemiac B-3 ^d	23	ϵ'/ϵ_0	3.19	3.12	3.09	3.04	3.00	2.98	2.98	2.91	2.90	2.87
		$\tan \delta$	105	85	86	91	100	110	118	125	135	120

6. Asphalts and Cements

Gilsonite ^e	26	ϵ'/ϵ_0	2.68	2.66	2.63	2.61	2.58	2.57	2.56	-----	-----	2.55
		$\tan \delta$	58	35	25	19	16	13	11	-----	-----	9.3
Millimar ^f	22	ϵ'/ϵ_0	2.65	2.65	2.65	2.64	2.64	2.64	2.64	-----	2.5	2.5
		$\tan \delta$	39	35	26	14	11	10	11	-----	11	12
Cenco Sealstix ^g	23	ϵ'/ϵ_0	3.90	3.75	3.55	3.37	3.23	3.13	3.13	-----	2.96	
		$\tan \delta$	452	335	275	240	240	272	272	-----	210	
Plicene Cement ^h	25	ϵ'/ϵ_0	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.47	2.40	2.35
		$\tan \delta$	43.9	35.5	28.9	25.9	25.5	22.2	15	-----	7.8	6.8

7. Waxes

Acravax C ⁱ	24	ϵ'/ϵ_0	2.60	2.58	2.57	2.55	2.54	2.53	2.52	-----	2.48	2.45
		$\tan \delta$	157	68	45	30	20	15	12	-----	15	19
	85	ϵ'/ϵ_0	-----	5.0	3.2	2.63	2.50	2.46	2.46	-----	2.45	
		$\tan \delta$	-----	7000	3500	560	180	130	130	-----	223	
Apiezon Wax "W" ^j	22	ϵ'/ϵ_0	2.75	2.69	2.66	2.64	2.63	2.63	2.63	-----	2.62	
		$\tan \delta$	186	120	70	39	25	19	19	-----	16	
	70	ϵ'/ϵ_0	3.29	3.14	2.97	2.88	2.82	2.79	2.79	-----	-----	
		$\tan \delta$	450	420	340	210	110	61	61	-----	16	

e. Contains ca. 3.5% wax (Zinsser). b. Natural, ca. 2% wax (Zinsser). c. Natural, wax-free (Zinsser). d. From zein and rosin (Flavored Rosin Products). e. 99.9% natural bitumen (U.S.Rubber). f. Asphaltic product (U.S.Rubber). g. De Khotinsky Cement (Central Scientific). h. Central Scientific. i. Central Scientific. j. Shell Oil.

I. Solids B. Organic

(cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	$\frac{7}{T^{\circ}\text{C}}$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\epsilon'/\epsilon_0}$	$\frac{3x10^10}{\epsilon'/\epsilon_0}$	$\frac{2.5x10^10}{\epsilon'/\epsilon_0}$
7. Waxes (cont.)											
	Bee蜡, white ^a	23	ϵ'/ϵ_0	2.65	2.63	2.56	2.48	2.43	2.41	2.39	2.35
			$\tan \delta$	140	118	266	190	84	68	60	48
										50	
		55	ϵ'/ϵ_0	2.52	2.50	2.46	2.43	2.39	2.36	2.34	2.31
			$\tan \delta$	82	44	25	25	35	58	125	216
	Bee蜡, yellow ^b	23	ϵ'/ϵ_0	2.73	2.66	2.59	2.53	2.49	2.45	2.42	2.39
			$\tan \delta$	240	140	240	150	92	84	90	75
		24*	ϵ'/ϵ_0	2.35	2.35	2.35	2.34	2.33	2.32	2.32	2.29
			$\tan \delta$	5	6	7	8	8	7	7	62
		46*	ϵ'/ϵ_0	2.35	2.35	2.35	2.34	2.33	2.32	2.32	2.27
			$\tan \delta$	< 5	< 3	3	5	8	10	10	
	Ceres Wax AA ^c	22	ϵ'/ϵ_0	----	2.28	2.28	2.28	2.28	2.28	2.27	2.27
			$\tan \delta$	----	5	10	13	11	7	2	
		25	ϵ'/ϵ_0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.28
			$\tan \delta$	8	6	5	5	4	4	4	5.0
	Ceresin, white ^d	20	ϵ'/ϵ_0	----	2.25	2.25	2.25	2.25	2.25	2.25	2.25
			$\tan \delta$	----	4	5	7	7	5	4	4.6
		25	ϵ'/ϵ_0	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.25
			$\tan \delta$	7	< 2	2	4	5	4	4	6.5
		80	ϵ'/ϵ_0	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.17
			$\tan \delta$	11	7	3	< 2	< 2	< 4	5	5
	Hallowax #1001 ^g	26	ϵ'/ϵ_0	5.45	5.45	5.45	5.40	5.40	5.30	4.2	3.46
			$\tan \delta$	18	17	7	8	45	450	2700	1620
	hot-molded	25	ϵ'/ϵ_0	3.78	3.78	3.76	3.74	3.70	3.62	3.37	2.57
			$\tan \delta$	16	8	6	8.6	32	400	1200	1210

a. Bromund. b. Candy. c. Mainly petroleum aliphatic hydrocarbons (Soccony-Vacuum). d. Vegetable and mineral waxes (Kuhne-Libby).

e. Vegetable and mineral waxes (Mitchell-Rand). f. Long-chain, singly unsaturated (Lovel). g. Tri- and tetrachloronaphthalenes (Bakelite).

*Similar data were obtained after incorporation of 0.5% phenyl mercuric stearate.

I. Solids B. Organic (Cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	$\frac{T^{\circ}C}{\epsilon' / \epsilon_0}$	$\frac{1x10^2}{\epsilon' / \epsilon_0}$	$\frac{1x10^3}{\epsilon' / \epsilon_0}$	$\frac{1x10^4}{\epsilon' / \epsilon_0}$	$\frac{1x10^5}{\epsilon' / \epsilon_0}$	$\frac{1x10^6}{\epsilon' / \epsilon_0}$	$\frac{1x10^7}{\epsilon' / \epsilon_0}$	$\frac{1x10^8}{\epsilon' / \epsilon_0}$	$\frac{3x10^8}{\epsilon' / \epsilon_0}$	$\frac{3.10^9}{\epsilon' / \epsilon_0}$	$\frac{1x10^{10}}{\epsilon' / \epsilon_0}$	$\frac{2.5x10^{10}}{\epsilon' / \epsilon_0}$
7. Waxes (cont.)												
Holloway #11-314 ^a	23	ϵ' / ϵ_0	3.11	3.04	3.01	2.99	2.98	2.96	2.93	2.92	2.89	2.87
	tan δ	700	110	17	5	3	7	17	38	37	37	9.5
	ϵ' / ϵ_0	3.11	3.04	3.01	2.99	2.98	2.96	2.93	---	---	---	2.87
Kel-F Wax #150 ^b	25	ϵ' / ϵ_0	3.01	2.97	2.91	2.75	2.52	2.35	2.25	2.24	2.23	2.22
	tan δ	83	93	252	510	540	425	270	218	113	90	31
Opalwax ^c	24	ϵ' / ϵ_0	13.2	10.3	7.0	4.3	3.2	2.9	2.7	2.55	2.52	2.5
	tan δ	1250	2100	2900	2700	1450	580	270	---	167	160	160
	ϵ' / ϵ_0	14.2	11.4	8.2	5.4	3.7	3.0	2.7	---	2.47	2.47	2.47
Ozokerite ^d	47	ϵ' / ϵ_0	2.26	2.26	2.26	2.26	2.26	2.26	2.26	---	2.26	2.26
	tan δ	450	1300	2600	3000	2100	860	430	---	236	236	236
Paraffin Wax 132° ASTM ^e	25	ϵ' / ϵ_0	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.24	2.2
	tan δ	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	2.0	2.1	< 3
	ϵ' / ϵ_0	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.00	2.00	2.00
Paraffin Wax 135° AMP ^f	24	ϵ' / ϵ_0	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.24	2.24
	tan δ	5	1.2	.5	< 2	< 2	< 2	< 3	---	5.2	5.2	5.2
Paraffin ^g	20	ϵ' / ϵ_0	----	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.22
	tan δ	----	2	2	2	2	3	2	1.4	1	1	2
Poneline ^h	25	ϵ' / ϵ_0	2.89	2.87	2.87	2.85	2.84	2.80	2.72	2.62*	2.59	2.58
	tan δ	67	44	36	43	82	166	240	180*	195	199	199
Sealing wax, Red Express ⁱ	25	ϵ' / ϵ_0	3.68	3.52	3.40	3.32	3.29	3.27	3.2	---	3.09	3.09
Thermoplastic Composition 25		ϵ' / ϵ_0	3.77	3.72	3.68	3.63	3.60	3.58	3.56	---	122	122
Thermoplastic Composition 25		ϵ' / ϵ_0	2.65	2.60	2.57	2.56	2.55	2.54	2.54	2.52*	2.52	2.52
3738 ^j		ϵ' / ϵ_0	112	91	67	41	25	16	15	13*	13	13

a. 80% 1,4-, 10% 1,5-, 10% 1,2-dichloronaphthalenes (Bakelite). b. Polychlorotrifluoroethylene (Kellogg). c. Mainly 12-hydroxystearin (DuPont). d. Natural paraffin (Allison). e. Mainly C₂₂ to C₂₉ aliphatic, saturated hydrocarbons (Stand. Oil N.J.). f. Gulf. g. Paraffin wax (Society Vacuum). h. Lovell. i. Dennison. j. Mitchell-Rand.

*Freq. = $1x10^9$.

I. Solids B. Organic (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	$\frac{1 \times 10^2}{T^\circ C}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$
7. Waxes (cont.)								
Thermoplastic composition 25	ϵ' / ϵ_0	2.84	2.79	2.76	2.64	2.59	2.51	2.48
3767A ^a	$\tan \delta$	140	160	170	120	98	69	59
Vistawax ^b	ϵ' / ϵ_0	2.34	2.34	2.34	2.34	2.32	2.30	----
	$\tan \delta$	2	3	9.2	12.1	13.3	13.3	9.0
Wax 3760 ^c	ϵ' / ϵ_0	2.36	2.36	2.36	2.36	2.36	2.36	2.31
	$\tan \delta$	21.7	8.8	7.1	5.6	4.3	2.7	3.6*
Wax S-1167 ^d	ϵ' / ϵ_0	19.9	10.2	5.9	4.1	3.3	2.9	2.6
	$\tan \delta$	7200	3900	2300	1700	1000	470	300
Wax S-1184 ^d	ϵ' / ϵ_0	2.43	2.43	2.40	2.40	2.40	2.37	2.30
	$\tan \delta$	29.4	21.5	16.4	11.3	9.3	13.8	20*
Wax Compound F-590 ^e	ϵ' / ϵ_0	2.37	2.34	2.32	2.32	2.32	2.32	----
	$\tan \delta$	80	99	78	44	20	8	5
Wax Compound #1340 ^e	ϵ' / ϵ_0	2.30	2.30	2.30	2.30	2.30	2.30	----
	$\tan \delta$	1	2	2	< 5	4	4	4
8. Woods								
Balsa	ϵ' / ϵ_0	1.4	1.4	1.4	1.4	1.37	1.30	----
	$\tan \delta$	50	40	43	77	120	135	----
Yellow Birch (field \perp to grain)	ϵ' / ϵ_0	2.91	2.88	2.82	2.78	2.70	2.60	2.47
Fir, Douglas (field \perp to grain)	ϵ' / ϵ_0	2.04	2.00	1.97	1.95	1.93	1.90	1.88
Fir, Douglas, plywood (field \perp to grain)	ϵ' / ϵ_0	2.1	2.1	2.05	1.95	1.90	1.80	1.77
Mahogany (field \perp to grain)	ϵ' / ϵ_0	7.3	7.05	6.9	6.65	6.3	5.6	4.6
Poplar, yellow (field \perp to grain)	ϵ' / ϵ_0	2.42	2.40	2.36	2.30	2.25	2.17	2.07

a. Mitchell-Rand. b. Polybutene (Cantol Wax). c. Mitchell-Rand. d. Glyco. e. Zophar Mills.

*Freq. = 1×10^9 .

I. Solids B. Organic (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	$T^{\circ}\text{C}$	$\frac{1x10^2}{\epsilon'/\epsilon_0}$	$\frac{1x10^3}{\epsilon'/\epsilon_0}$	$\frac{1x10^4}{\epsilon'/\epsilon_0}$	$\frac{1x10^5}{\epsilon'/\epsilon_0}$	$\frac{1x10^6}{\epsilon'/\epsilon_0}$	$\frac{1x10^7}{\epsilon'/\epsilon_0}$	$\frac{1x10^8}{\epsilon'/\epsilon_0}$	$\frac{3x10^3}{\epsilon'/\epsilon_0}$	$\frac{3x10^9}{\epsilon'/\epsilon_0}$	$\frac{1x10^{10}}{\epsilon'/\epsilon_0}$	$\frac{2.5x10^{10}}{\epsilon'/\epsilon_0}$
9. Miscellaneous Paper, Royalgrey ^a	25	ϵ'/ϵ_0	3.30	3.29	3.22	3.10	2.99	2.86	2.77	2.75	2.70	2.62
	tan δ	58	77	117	200	380	570	660	660	560	560	403
82	ϵ'/ϵ_0	3.57	3.52	3.49	3.40	3.31	3.14	3.08	3.00	2.94	2.84	
	tan δ	170	74	61	85	230	440	630	720	800	827	
Leather, sole, dried Leather, sole, ca. 15% moisture	25	ϵ'/ϵ_0	4.1	3.9	3.6	3.4	3.2	3.1	3.1	3.1	3.1	
	tan δ	450	350	300	280	280	300	300	300	380	380	
Soap, Ivory ^b	25	ϵ'/ϵ_0	38	14.0	9.3	6.9	5.6	4.9	4.9	4.5	4.5	
	tan δ	14000	7000	3700	2200	14000	10000	10000	10000	10000	10000	
Steak (bottom round)	25	ϵ'/ϵ_0	----	----	----	----	----	----	----	----	----	2.96
	tan δ	----	----	21400	----	197	50	----	50	40	30	15
Suet	25	ϵ'/ϵ_0	----	405000	----	610000	260000	----	7800	3000	3700	4000
	tan δ	----	750	210	----	14	4.5	2.6	2.5	2.5	2.4	2.4
			30000	25000	----	17000	9300	1500	1200	700	500	500

a. Rogers. b. Procter and Gamble.

II. LIQUIDS

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

A. Inorganic		$\frac{T}{^{\circ}C}$	$\frac{1}{\epsilon' / \epsilon_0}$	$\frac{1}{\epsilon' / \epsilon_0} \times 10^5$	$\frac{1}{\epsilon' / \epsilon_0} \times 10^6$	$\frac{1}{\epsilon' / \epsilon_0} \times 10^7$	$\frac{1}{\epsilon' / \epsilon_0} \times 10^8$	$\frac{1}{\epsilon' / \epsilon_0} \times 10^9$	$\frac{1}{\epsilon' / \epsilon_0} \times 10^{10}$	$\frac{1}{\epsilon' / \epsilon_0} \times 10^{10} \times 2$
Water, conductivity^a										
1.5	ϵ' / ϵ_0		87.0	87.0	87	87	86.5	80.5	38	15
	$\tan \delta$		1900	190	20	70	320	3100	10300	4250
5	ϵ' / ϵ_0		---	85.5	---	---	85.2	80.2	41	17.5
	$\tan \delta$		---	220	---	---	273	2750	9500	3950
15	ϵ' / ϵ_0		---	81.7	---	---	81.0	78.8	49	25
	$\tan \delta$		---	310	---	---	210	2050	7000	3300
25	ϵ' / ϵ_0		78.2	78.2	78	77.5	76.7	55	34	
	$\tan \delta$		4000	400	46	50	160	1570	5400	2650
35	ϵ' / ϵ_0		74.8	74.8	---	74.0	74.0	58	41	
	$\tan \delta$		---	485	---	---	125	1270	4400	2150
45	ϵ' / ϵ_0		71.5	71.5	---	71.0	70.7	59	46	
	$\tan \delta$		---	590	---	---	105	1060	4000	2750
55	ϵ' / ϵ_0		68.2	68.2	---	68	67.5	60	49	
	$\tan \delta$		---	720	---	---	92	890	3600	2450
65	ϵ' / ϵ_0		64.8	64.8	---	64.5	64.0	59	50.5	
	$\tan \delta$		---	865	---	---	84	765	3200	1250
75	ϵ' / ϵ_0		61.5	61.5	---	61	60.5	57	51.5	
	$\tan \delta$		---	1030	---	---	77	660	2800	1050
85	ϵ' / ϵ_0		58	58	58	58	57	56.5	54	
	$\tan \delta$		12400	1240	125	30	73	547	2600	
95	ϵ' / ϵ_0		55	55	---	52	52	52	50	
	$\tan \delta$		---	1430	---	---	70	470	---	6600
Aqueous sodium chloride^b										
0.1 molal solution	ϵ' / ϵ_0	25	78.2*	78.2*	---	---	76	75.5	54	
	$\tan \delta$		24,000,000	24,000,000	---	---	7800	2400	5600	
0.3 molal solution	ϵ' / ϵ_0	25	78.2*	78.2*	---	---	71	69.3	52	
	$\tan \delta$		63,000,000	63,000,000	---	---	24000	4350	6050	
0.5 molal solution	ϵ' / ϵ_0	25	78.2*	78.2*	---	---	69	67.0	51	
	$\tan \delta$		99,000,000	99,000,000	---	---	39000	6250	6300	
0.7 molal solution	ϵ' / ϵ_0	25	78.2*	78.2*	---	---	---	50	50	
	$\tan \delta$		130,000,000	130,000,000	---	---	---	---	---	

a. Research Laboratory of Physical Chemistry, M.I.T. b. NaCl, Mallinckrodt's Analytical Reagent.

*. ϵ' / ϵ_0 of conductivity water assumed for purpose of calculating $\tan \delta$ from conductivity measurements.

** Data of Collie, Hasted and Ritsch, Proc. Phys. Soc. 60, 145 (1948).

III. Liquids B. Organic Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	<u>T°C</u>	<u>$\frac{1}{\epsilon/\epsilon_0}$</u>	<u>$\frac{1}{\epsilon/\epsilon_0^2}$</u>	<u>$\frac{1}{\epsilon/\epsilon_0^3}$</u>	<u>$\frac{1}{\epsilon/\epsilon_0^4}$</u>	<u>$\frac{1}{\epsilon/\epsilon_0^5}$</u>	<u>$\frac{1}{\epsilon/\epsilon_0^6}$</u>	<u>$\frac{1}{\epsilon/\epsilon_0^7}$</u>	<u>$\frac{1}{\epsilon/\epsilon_0^8}$</u>	<u>$\frac{1}{\epsilon/\epsilon_0^9}$</u>	<u>$\frac{1}{\epsilon/\epsilon_0^{10}}$</u>
1. Aliphatic											
Heptane ^a	25	ϵ'/ϵ_0	1.971	1.971	1.971	1.971	1.971	1.971	1.971	1.971	1.971
		$\tan \delta$	< 3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Methyl alcohol ^b	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	-----	-----
		$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ethyl alcohol ^c	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	-----	-----
		$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----
n-Propyl alcohol ^d	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	-----	-----
		$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----
n-Butyl alcohol ^d	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	-----	-----
		$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ethylene Glycol ^e	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	-----	-----
		$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----
Butyraldehyde ^f	25	ϵ'/ϵ_0	-----	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
		$\tan \delta$	-----	51000	5200	5200	5200	5200	5200	5200	5200
Dibutyl sebacate ^f	26	ϵ'/ϵ_0	4.92	4.73	4.63	4.60	4.58	4.56	4.55	4.55	4.55
		$\tan \delta$	790	110	110	14	3	3	3	3	3
Diethyl sebacate ^f	26	ϵ'/ϵ_0	4.05	4.05	4.03	4.02	4.01	4.00	4.00	4.00	4.00
		$\tan \delta$	85	12	5	4	7	5	5	5	5
Carbon tetrachloride ^g	25	ϵ'/ϵ_0	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
		$\tan \delta$	60	8	0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Tetrachloroethylene ^h	25	ϵ'/ϵ_0	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
		$\tan \delta$	15	2	0.7	1	2	2	2	2	2
Hexachlorobutadiene ⁱ	25	ϵ'/ϵ_0	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
		$\tan \delta$	3	1.5	1	< 1	< 1	< 1	< 1	< 1	< 1

a. Practical (Solvents Supply Laboratory, M.I.T.). b. Absolute, analytical grade (Mallinckrodt). c. Absolute (U.S. Industrial Chemicals). d. Eastman Kodak. Dried and fractionated, Lab. Ins. Res. e. Eastman Kodak. f. Resinous Products. g. Purified, Lab. Ins. Res. h. Eastman Kodak, fractionated Lab. Ins. Res. i. Hooker, fractionated Lab. Ins. Res.

II. Liquids B. Organic (cont.)

Values for tan δ are multiplied by 10^4 ; frequency given in c./s.

	$\frac{1}{T^{\circ}C}$	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$	$\frac{3 \times 10^9}{\epsilon' / \epsilon_0}$
1. Aliphatic (Cont.)										
Dichloropentane #40 ^a	25	ϵ' / ϵ_0	-----	334	17.1	8.65	-----	7.76	7.57	6.81
	tan δ	-----	5200000	1060000	135300	-----	2700	-----	840	-----
Dichloropentane #14 ^a	25	ϵ' / ϵ_0	-----	8.24	8.06	8.05	8.05	-----	-----	1980
	tan δ	-----	7500	720	85	16	-----	-----	-----	-----
Kel-F Oil, Grade #1 ^b	25	ϵ' / ϵ_0	2.61	2.61	2.60	2.61	2.61	2.58	2.53	2.34
	tan δ	22	2.3	.3	1.3	2.0	17	140	380	870
Kel-F Oil, Grade #3 ^b	25	ϵ' / ϵ_0	2.73	2.73	2.73	2.73	2.73	2.73	2.48	2.22
	tan δ	7.9	.8	<.3	1.3	7.3	65	-----	930	696
Kel-F Oil, Grade #10 ^b	25	ϵ' / ϵ_0	2.83	2.83	2.83	2.83	2.83	2.78	2.40	2.26
	tan δ	2.1	.45	1.1	6.1	68	393	-----	820	300
Kel-F Grease #40 ^b	25	ϵ' / ϵ_0	2.88	2.88	2.88	2.86	2.78	2.57	2.25	2.20
	tan δ	5.4	3.8	18	111	430	570	-----	350	140
Perfluorodihexyl ether (experimental) ^c	25	ϵ' / ϵ_0	1.871	1.871	1.871	1.87	1.87	1.87	1.86	1.86
	tan δ	0.8	0.3	<.4	-----	3.3	3.5	-----	55	122
Heptacosafluorotributyl amine (exp.) ^c	25	ϵ' / ϵ_0	1.853	1.853	1.853	1.853	1.85	1.85	1.85	1.85
	tan δ	.15	<.1	<1	<1	<1	1.2	11	25	26
2. Aromatic										
HB-40 oil ^d	25	ϵ' / ϵ_0	2.59	2.59	2.59	2.59	2.58	2.57	2.54	2.48
	tan δ	1.3	<.4	<.4	<3	13	76	160	93	30
Pyranol 1467 ^e	25	ϵ' / ϵ_0	4.42	4.40	4.40	4.40	4.40	4.40	3.19	2.84
	tan δ	36	3	<4	3.6	25	260	1300	1500	1200
Aroclor 1221 ^f	25	ϵ' / ϵ_0	-----	-----	-----	4.55	4.53	4.35	3.85	2.75
	tan δ	-----	-----	-----	-----	9	80	800	2000	1030
Aroclor 1232 ^g	25	ϵ' / ϵ_0	-----	-----	-----	5.88	5.85	4.60	3.65	3.00
	tan δ	-----	-----	-----	-----	22	220	2600	3240	2000
Aroclor 1242 ^h	25	ϵ' / ϵ_0	-----	-----	-----	5.89	5.85	3.50	2.93	2.80
	tan δ	-----	-----	-----	-----	70	700	3000	1850	780
Aroclor 1248 ⁱ	25	ϵ' / ϵ_0	-----	-----	5.58	5.57	5.10	2.80	2.76	2.78
	tan δ	-----	-----	-----	26	260	1900	1000	410	300
Aroclor 1254 ^j	25	ϵ' / ϵ_0	-----	5.05	5.04	3.70	2.90	2.75	2.72	2.71
	tan δ	-----	-----	42	415	2380	1130	170	78	52

^a. Samples. ^b. Polychlorotrifluoroethylene (Kellogg). ^c. Minn. Mining. ^d. Monsanto. ^e. Chlorinated benzenes and diphenyls (Gen. Elec.). ^f. Monochlorobiphenyl (Monsanto). ^g. Dichlorobiphenyl (Monsanto). ^h. Trichlorobiphenyl (Monsanto). ⁱ. Tetrachlorobiphenyl (Monsanto). ^j. Pentachlorobiphenyl (Monsanto).

II. Liquids B. Organic (cont.)

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

2. Aromatic (cont.)	$\frac{\text{m}^2}{\text{C}}$	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\epsilon' / \epsilon_0}$
Pyracel 1476 ^a	26	ϵ' / ϵ_0 5.04	5.04	5.04	4.91	3.85	2.81	2.74	2.70
Pyracel 1476 ^a		tan δ .6	.6	.54	480	2500	1100	130	42
Aroclor 1260 ^b	25	ϵ' / ϵ_0 4.33	4.26	3.46	2.89	2.83	2.79	2.73	2.72
Aroclor 1262 ^c	25	ϵ' / ϵ_0 4.03	3.44	2.86	2.76	2.75	2.75	2.75	2.75
Aroclor 5442 ^d	25	ϵ' / ϵ_0 -----	-----	-----	-----	46	15.7	-----	5.0
Halowax oil 1000 ^e	25	ϵ' / ϵ_0 4.77	4.76	4.76	4.75	4.74	4.67	4.67	2.78
Halowax oil 1000 ^e		tan δ 490	50	5	< 1	< 2	-----	500	2500
	80	ϵ' / ϵ_0 4.30	4.30	4.30	4.29	4.26	4.16	4.16	3.30
		tan δ 7800	930	80	15	11	170	1400	2800
Nitrobenzene ^f	25	ϵ' / ϵ_0 -----	-----	36	36	35.6	34.4	34.4	31.1
		tan δ -----	-----	3900	350	80	90	90	1660
Styrene N-100 ^g	22	ϵ' / ϵ_0 2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Styrene N-100 ^g purified ^h	25	ϵ' / ϵ_0 2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Styrene N-100, ^g sat. with water	27	ϵ' / ϵ_0 2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Styrene dimer ⁱ	25	ϵ' / ϵ_0 -----	-----	4.8	1.8	-----	-----	-----	14
2,5-Dichlorostyrene ^j	24	ϵ' / ϵ_0 2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58
β -chloroethyl-2,5- dichlorobenzene ^k (discontinued)	26	ϵ' / ϵ_0 4.55	4.53	4.53	4.53	4.53	4.53	4.53	4.50
Ethylpolychlorobenzene ^m	25	ϵ' / ϵ_0 4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12
		tan δ 13.6	1.3	1	< 2	6	55	55	55
	100	ϵ' / ϵ_0 3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
		tan δ 380	40	3.7	< 1	1	5	5	5

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^a. Isomeric pentachlorodiphenyls (Gen. Elec.). ^b. Hexachlorobiphenyl (Monsanto). ^c. Hectachlorobiphenyl (Monsanto). ^d. Pentachlorobiphenyl (Monsanto). ^e. 60% mono-, 40% di- and trichloronaphthalenes (Bakelite). ^f. Purified Lab. Ins. Res. ^g. Dow Chemical Co. ^h. Fractionated (Lab. Ins. Res.). ⁱ. Monsanto (fractionated Lab. Ins. Res.). ^j. Isomeric trichlorobenzenes (Gen. Elec.). ^k. Monsanto. ^m. DuPont.

III. Liquids, B. Organic (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	<u>T_C</u>	<u>1x10²</u>	<u>1x10³</u>	<u>1x10⁴</u>	<u>1x10⁵</u>	<u>1x10⁶</u>	<u>1x10⁷</u>	<u>1x10⁸</u>	<u>3x10⁹</u>	<u>1x10¹⁰</u>
3. Petroleum Oils										
Aviation gasoline	25	ϵ'/ϵ_0	-----	1.94	-----	-----	-----	-----	1.94	1.92
100 octane		tan δ	-----	1	-----	-----	-----	-----	.8	14
Aviation gasoline	25	ϵ'/ϵ_0	-----	1.95	-----	-----	-----	-----	1.95	1.94
91 octane		tan δ	-----	4	-----	-----	-----	-----	.4	11.5
Jet fuel JP-1	25	ϵ'/ϵ_0	-----	2.12	-----	-----	-----	-----	2.12	2.09
		tan δ	-----	< 1	-----	-----	-----	-----	12	68
Jet fuel JP-3	25	ϵ'/ϵ_0	-----	2.08	-----	-----	-----	-----	2.08	2.04
		tan δ	-----	< 1	-----	-----	-----	-----	7	55
Kerosene	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	2.09
		tan δ	-----	-----	-----	-----	-----	-----	-----	45
Vaseline	25	ϵ'/ϵ_0	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16
		tan δ	3	2	< 2	< 1	< 1	< 1	-----	6.6
	80	ϵ'/ϵ_0	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
		tan δ	16	3.6	.9	< 1	< 1	-----	-----	9.2
Cable Oil 5314 ^a	25	ϵ'/ϵ_0	2.25	2.25	2.25	2.25	2.25	2.25	2.24	2.22
		tan δ	3	< 0.4	< 0.4	< 1	-----	-----	39	18
	80	ϵ'/ϵ_0	2.18	2.18	2.18	2.18	2.18	2.18	-----	2.18
Transil 011 10C ^b	26	ϵ'/ϵ_0	2.20	2.19	2.18	2.18	2.17	2.17	2.17	2.16
		tan δ	38	4	0.5	-----	-----	-----	-----	47
Bayol-D ^c	24	ϵ'/ϵ_0	2.22	2.22	2.22	2.22	2.22	2.20	2.19	2.18
		tan δ	4	< 1	< 1	< 6	< 5	51	55	20
Bayol-F ^d	24	ϵ'/ϵ_0	2.14	2.14	2.14	2.14	2.14	2.06	2.06	2.06
		tan δ	6.7	1.6	< 1	< 2	< 3	48	55	28
Marcol ^e	24	ϵ'/ϵ_0	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.13
		tan δ	1	< 1	< 1	< 2	< 2	< 3	-----	9.7

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^a. Aliphatic and aromatic hydrocarbons (Gen. Elec.). ^b. California Res. Corp. c. 77.6% paraffins, 22.1% naphthenes (Stanco).

d. 74.5% paraffins, 25.5% naphthenes (Stanco). e. 72.1% paraffins, 27.6% naphthenes (Stanco).

II. Liquids, B. Organic (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c./s.

		<u>T°C</u>	<u>ϵ'/ϵ_0</u>	<u>1×10^2</u>	<u>1×10^3</u>	<u>1×10^4</u>	<u>1×10^5</u>	<u>1×10^6</u>	<u>1×10^7</u>	<u>1×10^8</u>	<u>3×10^8</u>	<u>3×10^9</u>	<u>1×10^{10}</u>	<u>2.5×10^{10}</u>
3. Petroleum Oils (cont.)														
Bayol ^a	24		ϵ'/ϵ_0	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14
Bayol-16 ^b	24		ϵ'/ϵ_0	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
Fractol A ^c	26		ϵ'/ϵ_0	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
Primol-D ^d	24		ϵ'/ϵ_0	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
Diala Oil 15 ^e	25		ϵ'/ϵ_0	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16
4. Silicones														
DC500	-15		ϵ'/ϵ_0	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
0.65 cs. at 25°C ^f	22		ϵ'/ϵ_0	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
DC500	23		ϵ'/ϵ_0	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66
10 cs. at 25°C ^f	22		ϵ'/ϵ_0	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76
DC500	23		ϵ'/ϵ_0	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76
100 cs. at 25°C ^f	22		ϵ'/ϵ_0	0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
DC200	23		ϵ'/ϵ_0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
100 cs. at 25°C ^f	22		ϵ'/ϵ_0	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78
DC200	22		ϵ'/ϵ_0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
1000 cs. at 25°C ^f	7600		ϵ'/ϵ_0	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90
DC200	-17		ϵ'/ϵ_0	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75
7600 cs. at 130°C ^f	23		ϵ'/ϵ_0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
83			ϵ'/ϵ_0	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56

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a. 72.0% paraffins, 28.0% naphthenes (Stanco). b. 68.9% paraffins, 31.1% naphthenes (Stanco). c. 57.4% paraffins, 42.6% naphthenes (Stanco). d. 49.4% paraffins, 50.6% naphthenes (Stanco). e. Petroleum hydrocarbons, mainly naphthenes (Shell). f. Methyl or ethyl siloxane polymer (Dow Corning).

III. Liquids, B. Organic (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

	<u>T°C</u>	<u>1×10^2</u>	<u>1×10^3</u>	<u>1×10^4</u>	<u>1×10^5</u>	<u>1×10^6</u>	<u>1×10^7</u>	<u>1×10^8</u>	<u>3×10^8</u>	<u>3×10^9</u>	<u>1×10^{10}</u>
<u>4. Silicones (cont.)</u>	ϵ'/ϵ_0	2.91	2.90	2.90	2.90	2.90	2.88	---	2.88	2.77	2.60
	$\tan \delta$	1630	170	18	3.7	3.8	12	---	130	210	220
<u>DC710^a</u>	ϵ'/ϵ_0	2.98	2.98	2.98	2.98	2.98	2.97	---	2.93	2.79	2.60
	$\tan \delta$	13	1.6	$.7$	3	10	50	---	200	140	170
<u>Ignition Sealing Compound #4^b</u>	ϵ'/ϵ_0	2.75	2.75	2.75	2.75	2.75	2.75	2.74	2.72	2.65	2.49
	$\tan \delta$	15	6	5	4	4	6	15	28	92	270
<u>SR96-40^c</u>	ϵ'/ϵ_0	2.6	2.6	2.6	2.6	2.6	2.6	---	---	2.54	
	$\tan \delta$	64	18	6	4	<4	---	---	---	47	
<u>SR96-100^c</u>	ϵ'/ϵ_0	2.71	2.71	2.71	2.71	2.71	2.71	---	2.71	2.70	2.67
	$\tan \delta$	$<.3$	$<.03$	$<.03$	$<.3$	<1	<1	---	11	95	186
<u>SR96-1000^c</u>	ϵ'/ϵ_0	2.73	2.73	2.73	2.73	2.73	2.73	---	2.73	2.71	2.69
	$\tan \delta$	$<.6$	$<.06$	$<.03$	<1	<1	<1	---	11	107	200

^a, Methyl and methyl phenyl polysiloxane (Dow Corning). ^b, Organosiloxane polymer (Dow Corning). ^c, Gen. Elec.

Supplementary High-Temperature Data on Plastics

$\frac{T}{^{\circ}C}$	$\frac{\epsilon' / \epsilon_0}{\tan \delta}$	Frequency given in c/s.					
		10^2	10^3	10^4	4×10^4	10^5	10^6
Formica FF-41 (after 5 yrs. storage, various samples)							
25	ϵ' / ϵ_0	6.27	6.19	6.12	6.08	5.97	-----
	$\tan \delta$	.018	.0085	.0081	.0090	.012	3.87
100	ϵ' / ϵ_0	-----	11.2	6.75	6.23	6.07	4.2
	$\tan \delta$	-----	.50	.18	.055	.040	.021
Formica LG (after 5 yrs. storage)							
25	ϵ' / ϵ_0	5.92	5.32	5.01	4.87	4.86	4.3
	$\tan \delta$	.112	.057	.038	.036	.040	.020
100	ϵ' / ϵ_0	-----	16.0	8.16	6.69	6.22	4.10
	$\tan \delta$	-----	.42	.29	.173	.151	-----
Formica MF-66							
200	ϵ' / ϵ_0	-----	12.8	7.17	6.4	.042	.037
	$\tan \delta$	-----	.847	.245	.134	.060	-----
100	ϵ' / ϵ_0	9.77	6.66	5.87	5.66	.046	4.10
	$\tan \delta$	.42	.195	.073	.046	.035	.067
Formica XX							
100	ϵ' / ϵ_0	9.39	6.75	6.14	6.03	.029	4.94
	$\tan \delta$	.44	.16	.043	.022	-----	.059
Micarta 259							
200	ϵ' / ϵ_0	12.8	6.7	5.0	4.8	4.75	5.2
	$\tan \delta$	.59	.36	.158	.081	.046	.102
Micarta 496 (after 5 yrs. storage)							
25	ϵ' / ϵ_0	7.31	6.35	5.89	5.73	5.44	.025
	$\tan \delta$	.16	.074	.045	.041	4.6	4.4
100	ϵ' / ϵ_0	-----	15.5	8.53	7.42	7.26	6.31
	$\tan \delta$	-----	.68	.305	.178	.116	.064

Supplementary High-Humidity Data

		Frequency given in c/s.								
<u>T₀C</u>		<u>10²</u>	<u>10³</u>	<u>10⁴</u>	<u>10⁵</u>	<u>10⁶</u>	<u>10⁷</u>	<u>4x10⁷</u>	<u>3x10⁸</u>	<u>10¹⁰</u>
Mycalox 400, dry	ϵ'/ϵ_0	7.45	7.45	7.42	7.40	7.39	7.38	7.36	7.36	7.12
	tan δ	.0029	.0019	.0016	.0014	.0013	.0013	.0012	----	.0033
after 48 hrs. in H ₂ O	ϵ'/ϵ_0	7.45	7.45	7.42	7.42	7.39	7.38	7.36	7.36	7.18
	tan δ	.012	.0097	.0068	----	.0029	.0021	.0019	----	.010
Bakelite BM 120, dry	ϵ'/ϵ_0	4.87	4.74	4.62	4.50	4.36	4.36	4.36	4.36	4.36
	tan δ	.030	.022	.020	.021	.021	.021	.021	.021	.021
after 19 days, 90% rel. hum.	ϵ'/ϵ_0	7.4	5.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
	tan δ	.32	.19	.11	.11	.11	.11	.11	.11	.11
after 18 mos., 90% rel. hum.	ϵ'/ϵ_0	11.1	7.8	6.3	5.4	4.54	4.54	4.54	4.54	4.54
	tan δ	.37	.20	.12	.078	.056	.056	.056	.056	.056
Bakelite BM 262, dry	ϵ'/ϵ_0	4.85	4.80	4.74	4.72	4.67	4.67	4.67	4.67	4.67
	tan δ	.0095	.0082	.0075	.0060	.0055	----	----	----	----
after 20 days, 90% rel. hum.	ϵ'/ϵ_0	3.87	3.78	3.70	3.70	3.70	3.70	3.70	3.70	3.70
	tan δ	.0184	.015	.012	----	----	----	----	----	----
after 7 mos., 90% rel. hum.	ϵ'/ϵ_0	6.72	5.78	5.15	5.15	5.15	5.15	5.15	5.15	5.15
	tan δ	.147	.09	.057	----	----	----	----	----	----
after 19 mos., 90% rel. hum.	ϵ'/ϵ_0	9.10	6.75	5.51	5.51	5.51	5.51	5.51	5.51	5.51
	tan δ	.244	.169	.111	----	----	----	----	----	----
Bakelite BM 1895, dry	ϵ'/ϵ_0	4.80	4.72	4.70	4.67	4.64	4.64	4.64	4.64	4.64
	tan δ	.0087	.0077	.0080	.0065	.0052	----	----	----	----
after 20 days, 90% rel. hum.	ϵ'/ϵ_0	5.1	5.0	4.9	4.9	4.9	4.9	4.9	4.9	4.9
	tan δ	.023	.018	.016	----	----	----	----	----	----
after 19 mos., 90% rel. hum.	ϵ'/ϵ_0	----	61.4	24	11.7	8.0	8.0	8.0	8.0	8.0
	tan δ	----	1.04	.75	.41	.22	----	----	----	----
Formica FF-55, dry	ϵ'/ϵ_0	----	----	----	----	----	----	----	----	5.55
	tan δ	----	----	----	----	----	----	----	----	.027
after 20 hrs. in H ₂ O	ϵ'/ϵ_0	----	----	----	----	----	----	----	----	6.5
	tan δ	----	----	----	----	----	----	----	----	.054

Supplementary High-Humidity Data (cont.)

	<u>T°C</u>	Frequency given in c/s.				
		<u>10²</u>	<u>10³</u>	<u>10⁴</u>	<u>10⁵</u>	<u>10⁶</u>
GMC Melamine, dry	25	ϵ'/ϵ_0	8.2	7.0	6.7	6.4
		tan δ	.19	.069	.019	.011
after 6 or 8 mos., 90% rel.hum.	25	ϵ'/ϵ_0	42.5	16.8	10.4	7.65
		tan δ	.75	.54	.27	.10
Hysol 6030, dry and after 4 days in H ₂ O, no change at 1x10 ⁹ .			---	---	---	2.74
Lucite HM-119, dry and after 18 months at 90% relative humidity, 25°C, no change in the range 10 ² to 10 ⁶ c/s.			---	---	---	2.74
Lumarith 22361, dry	25	ϵ'/ϵ_0	---	---	---	---
		tan δ	---	---	---	---
after 20 days or more at 90% rel. hum.	25	ϵ'/ϵ_0	---	---	---	0.0196
		tan δ	---	---	---	3.14
Micarta 496, dry	25	ϵ'/ϵ_0	---	---	---	0.047
		tan δ	---	---	---	3.78
after 24 hrs., 90% rel. hum.	25	ϵ'/ϵ_0	---	---	---	.059
		tan δ	---	---	---	3.94
Nylon, See page 23			---	---	---	.071
Poly-2,5-dichlorostyrene, dry	25	ϵ'/ϵ_0	---	---	---	2.59
		tan δ	---	---	---	.00026
after 20 days, 90% rel. hum.	25	ϵ'/ϵ_0	---	---	---	2.59
		tan δ	---	---	---	.00055
Polystyrene, See pages 36 and 37			---	---	---	2.26
Polythene, dry	25	ϵ'/ϵ_0	---	---	---	.00067
		tan δ	---	---	---	2.26
after 10 days, 90% rel. hum.	25	ϵ'/ϵ_0	---	---	---	.00085
		tan δ	---	---	---	2.26
Teflon, dry and after 18 months at 90% relative humidity, 25°C, no change in the range 10 ² to 10 ⁶ c/s.			---	---	---	2.26
Vinylite VU-1900,			---	---	---	2.26

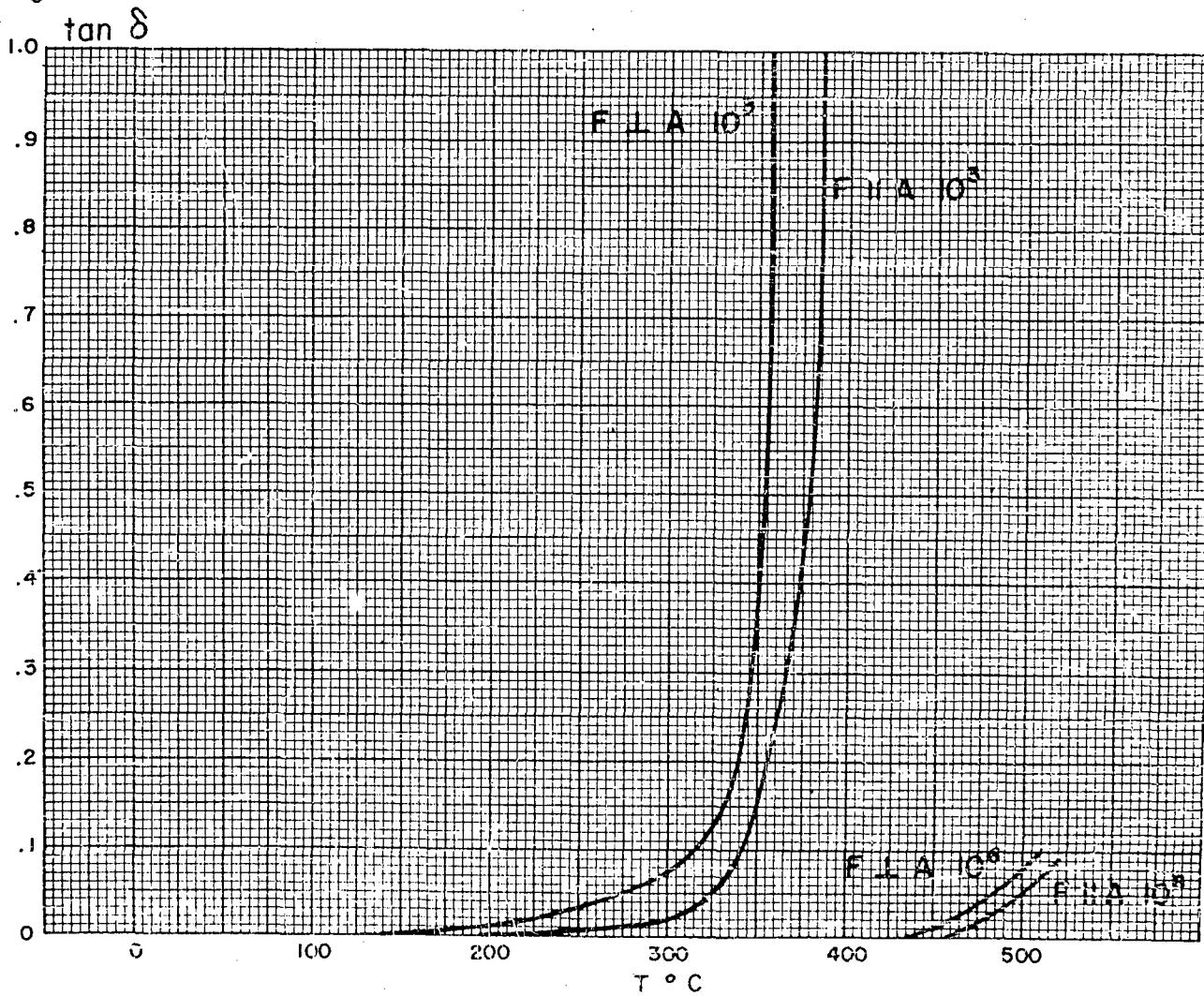
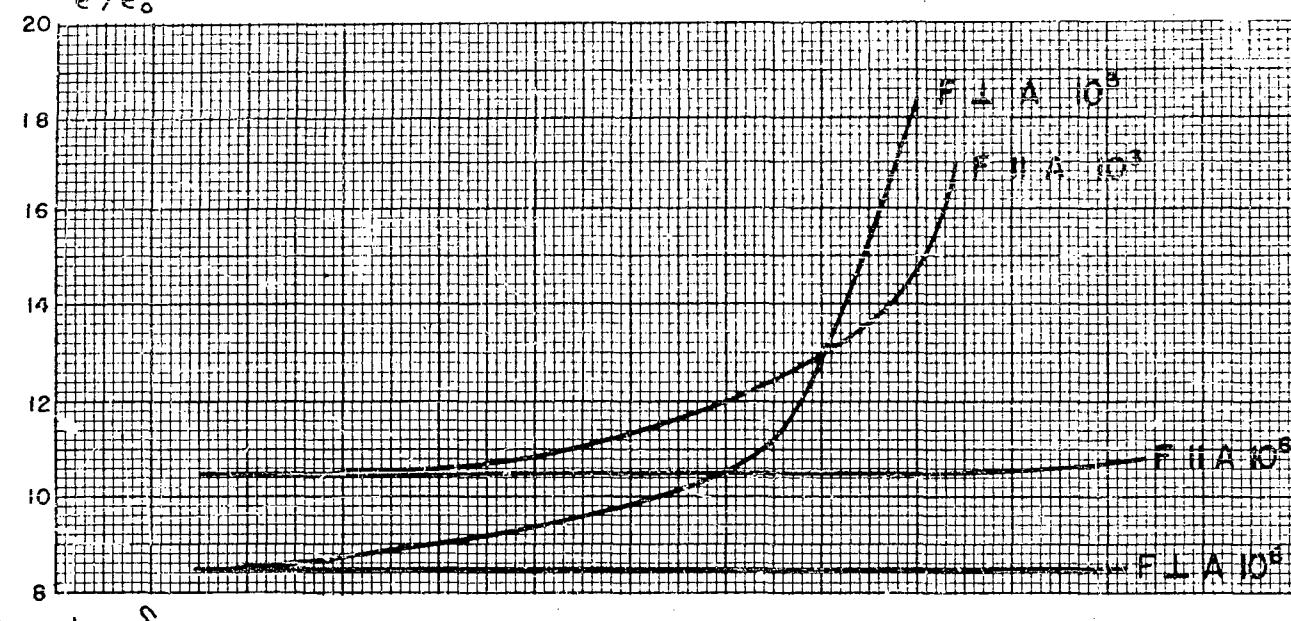
Data at Fixed Frequency as a Function of Temperature

Inorganic Crystals

Aluminum oxide, sapphire*

Linde Air

ϵ'/ϵ_0

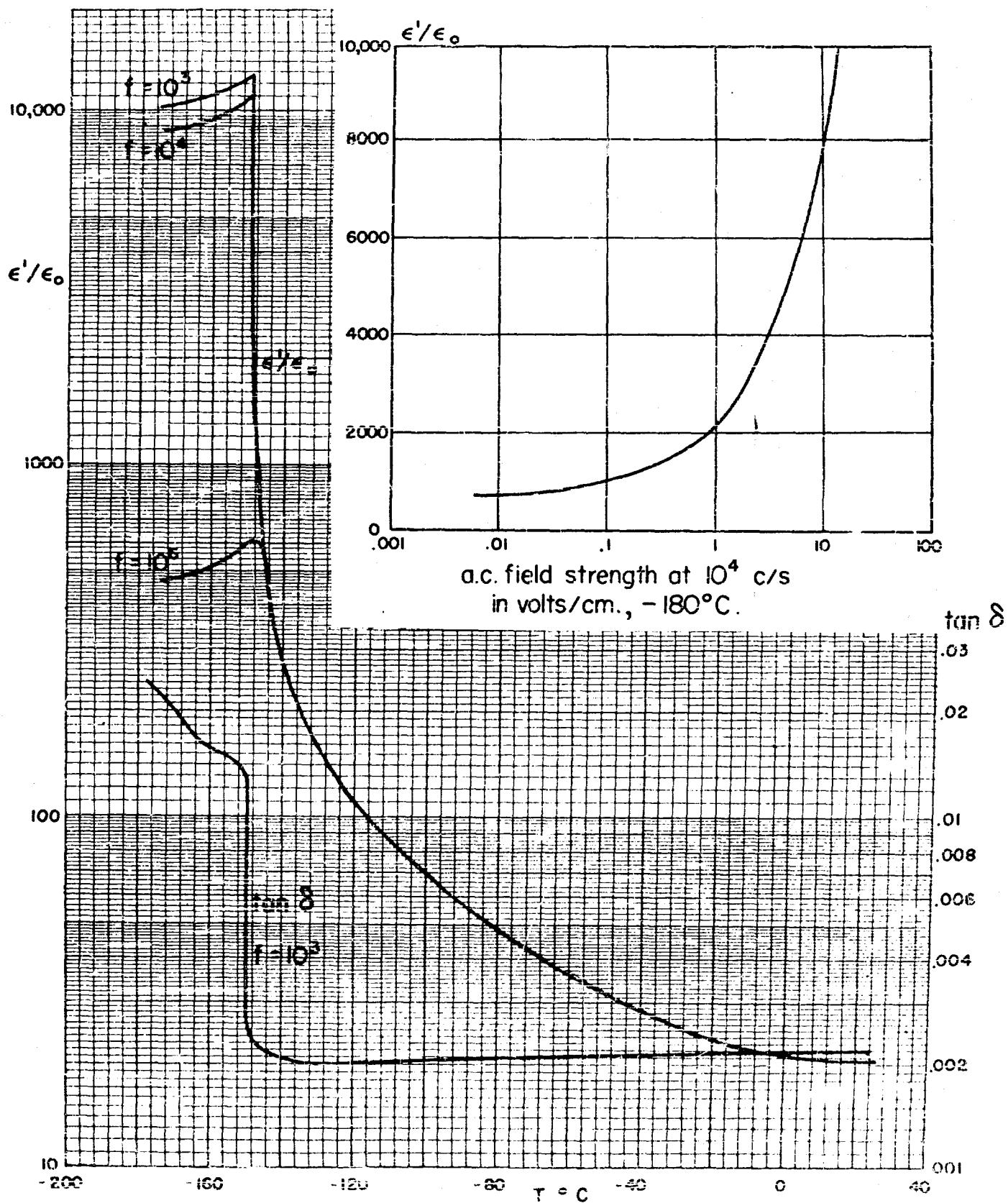


*Field I to optic axis and field II to optic axis.

Inorganic Crystals (cont.)

Potassium dihydrogen phosphate*

Brush

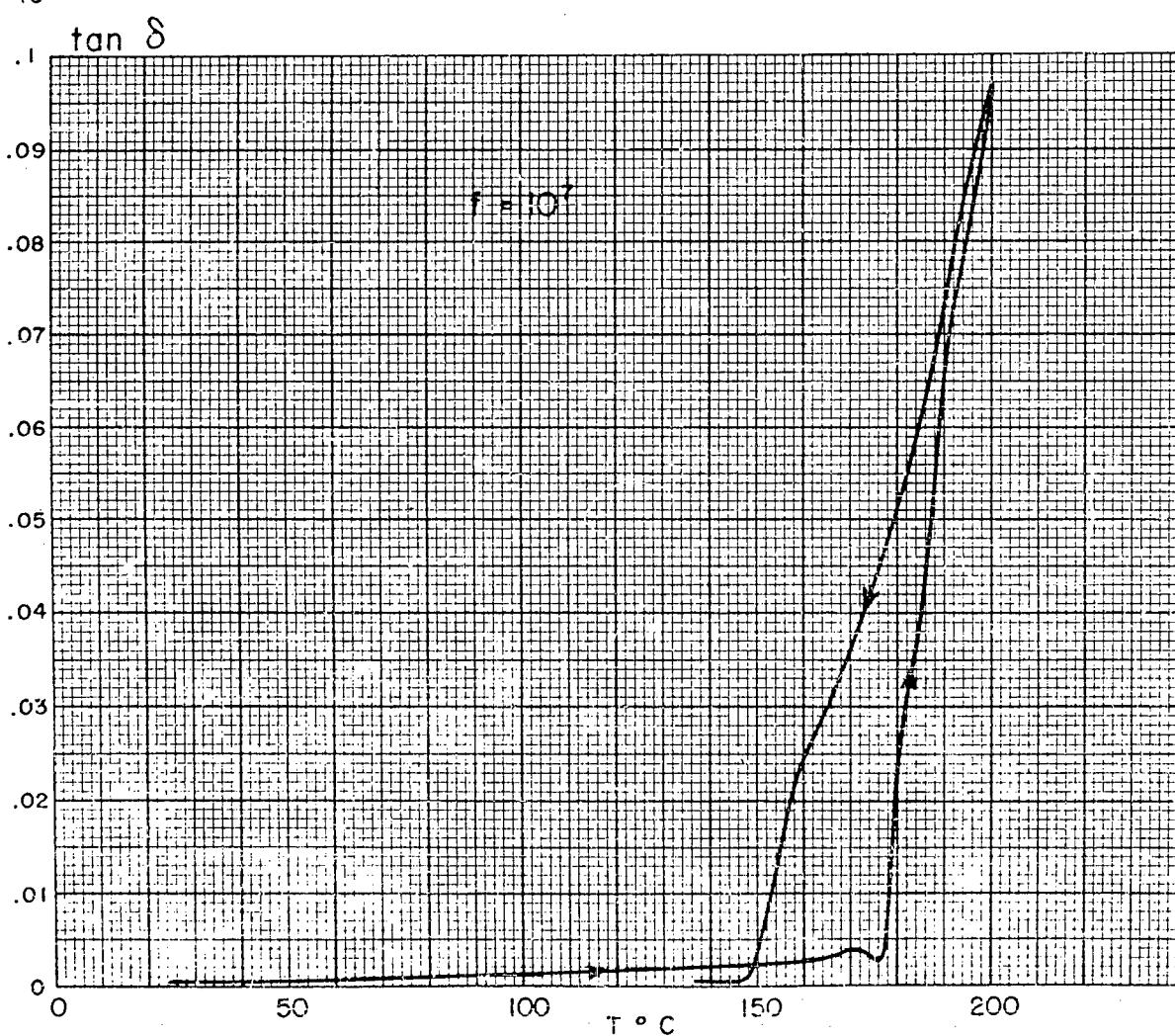
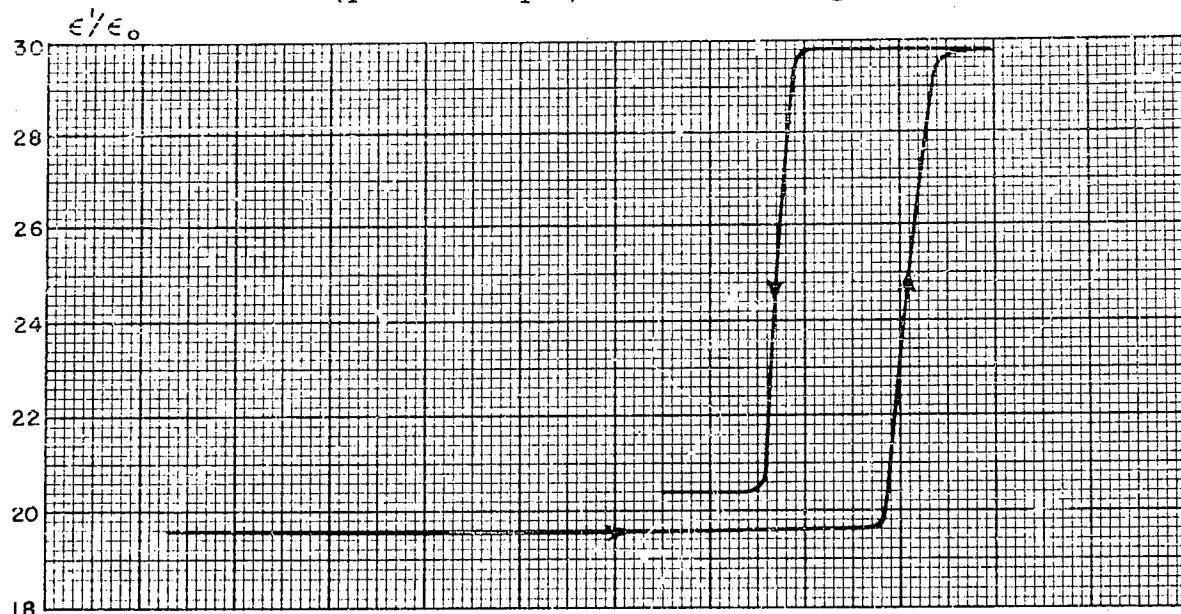


*Field II to optic axis, 15 volts/cm.

Inorganic Crystals (cont.)

Thallium iodide (pressed sample)

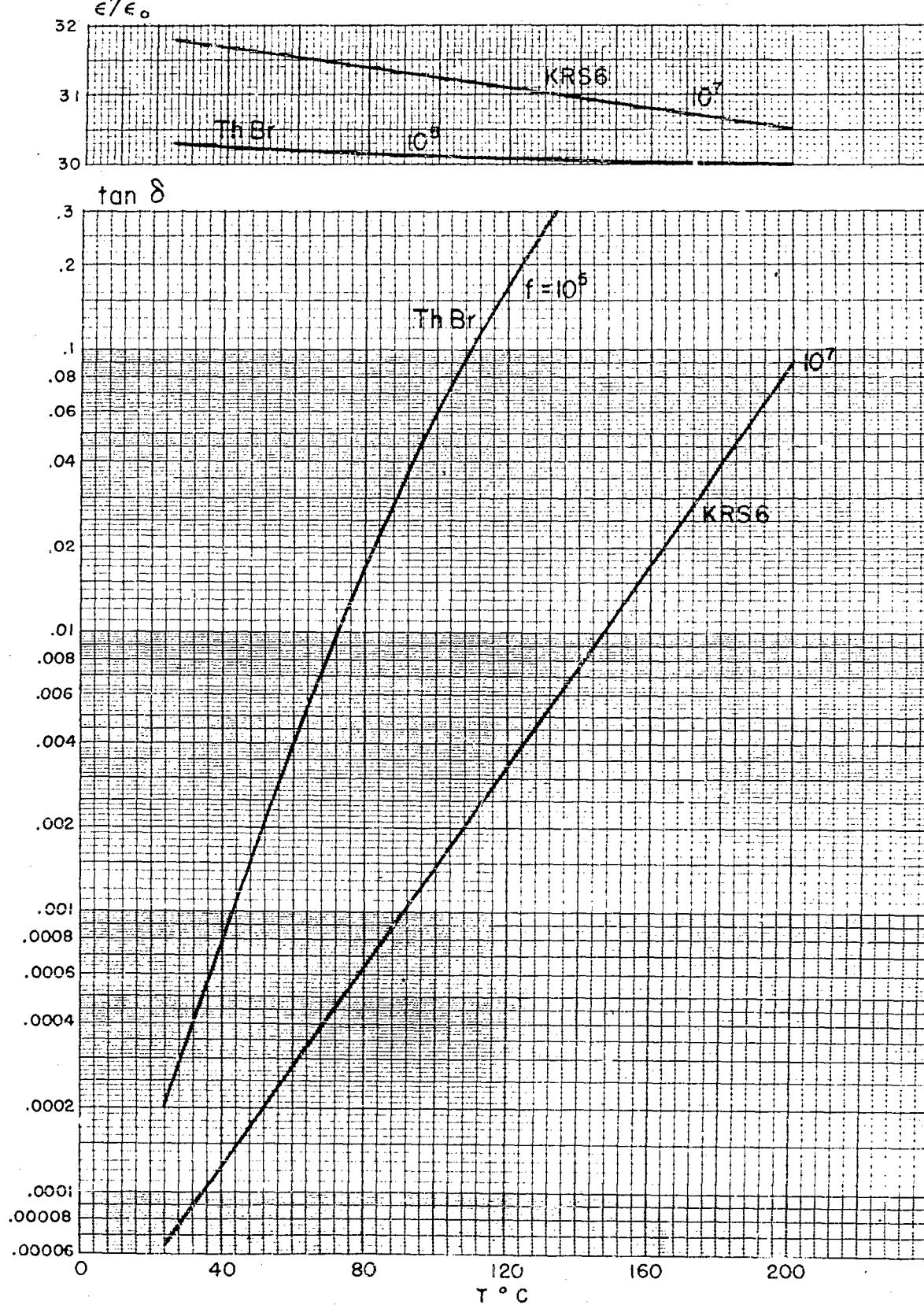
Eng. Res. and Dev. Lab.



Inorganic Crystals (cont.)

KRS-6 (ThCl₃, 40%, ThBr₃, 60%)
Thallium bromide

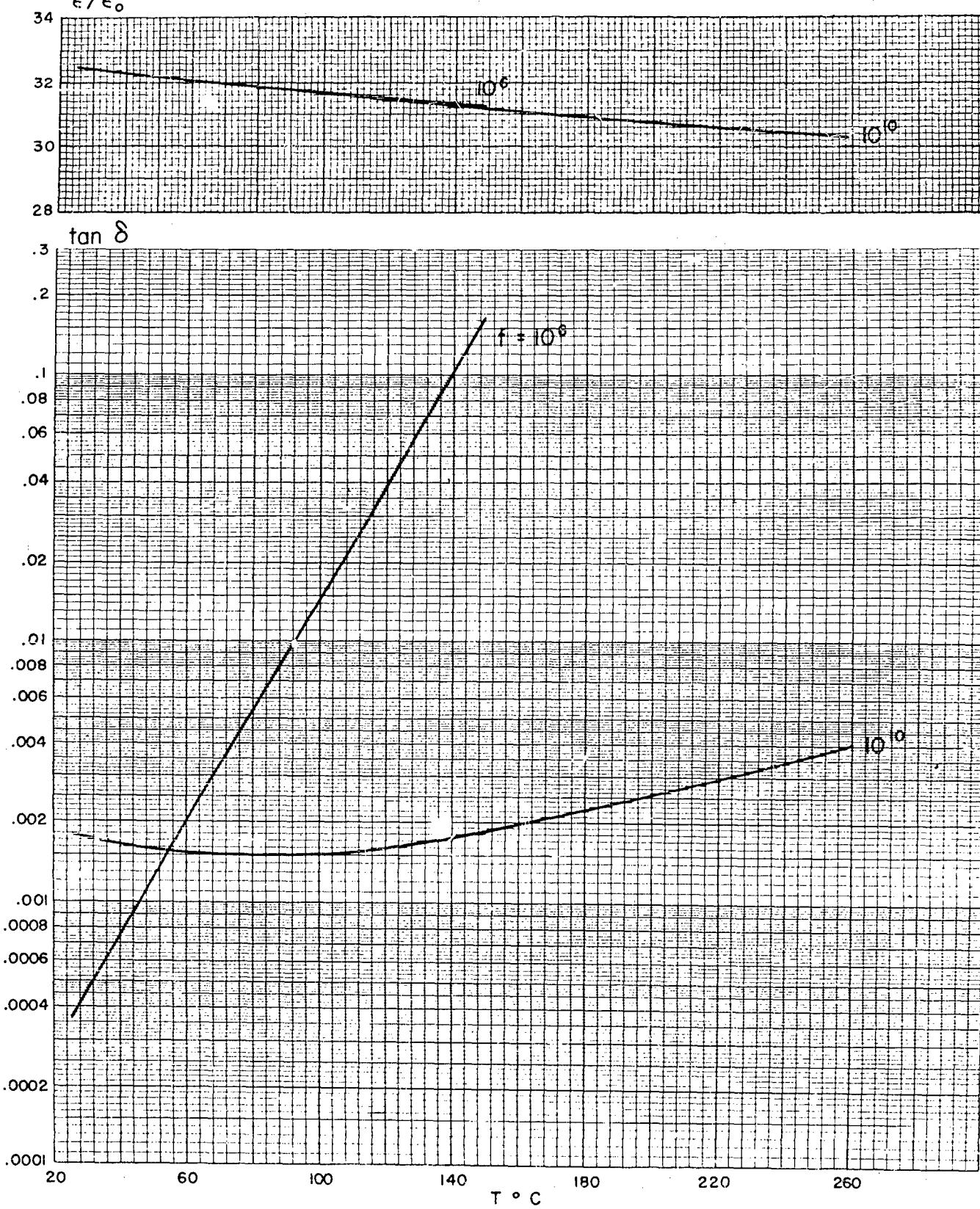
Eng. Res. and Dev. Lab.



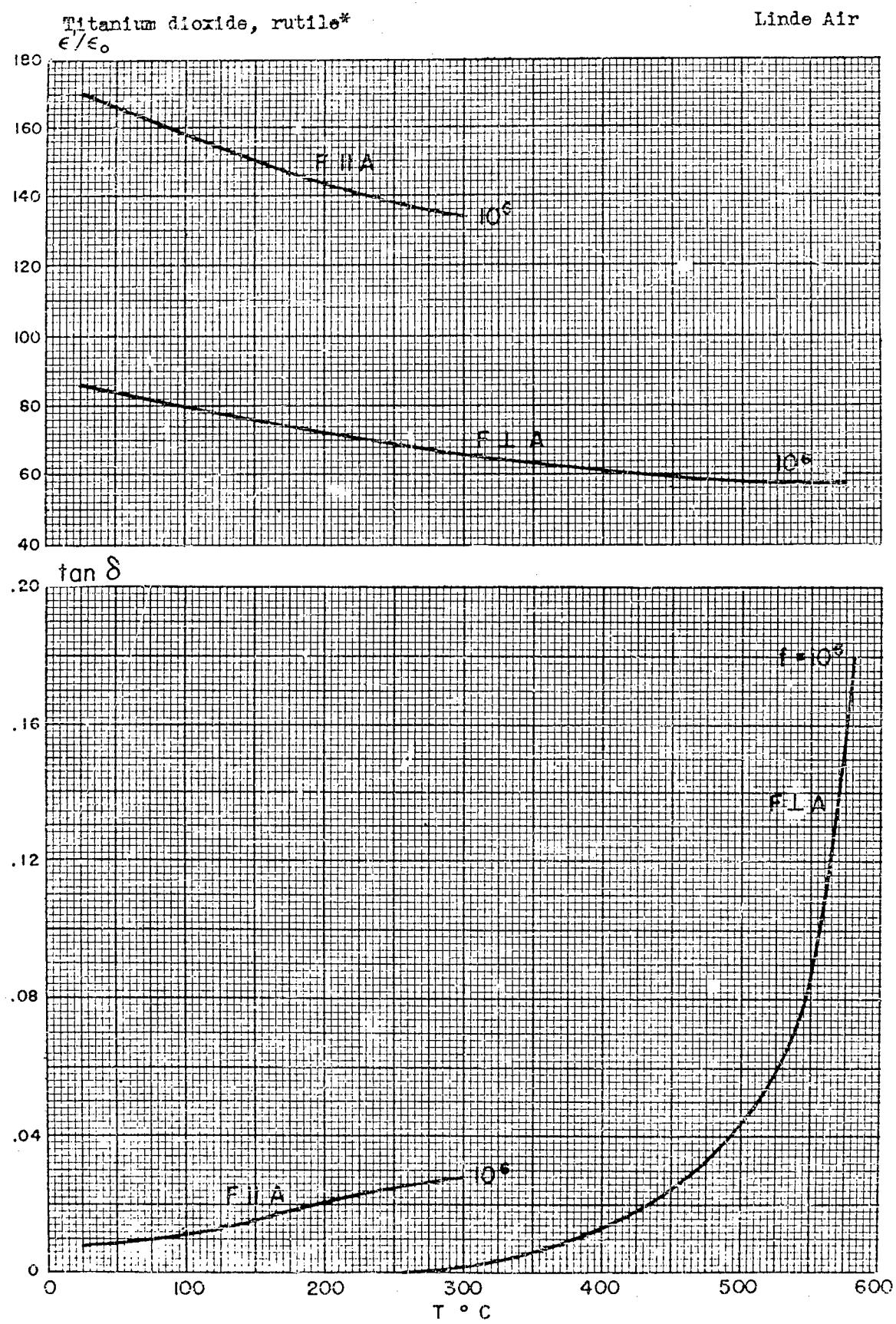
Inorganic Crystals (cont.)

KRS-5 (ThBr, 42%, ThI, 58%)
 ϵ'/ϵ_0

Eng. Res. and Dev. Lab.



Inorganic Crystals (cont.)

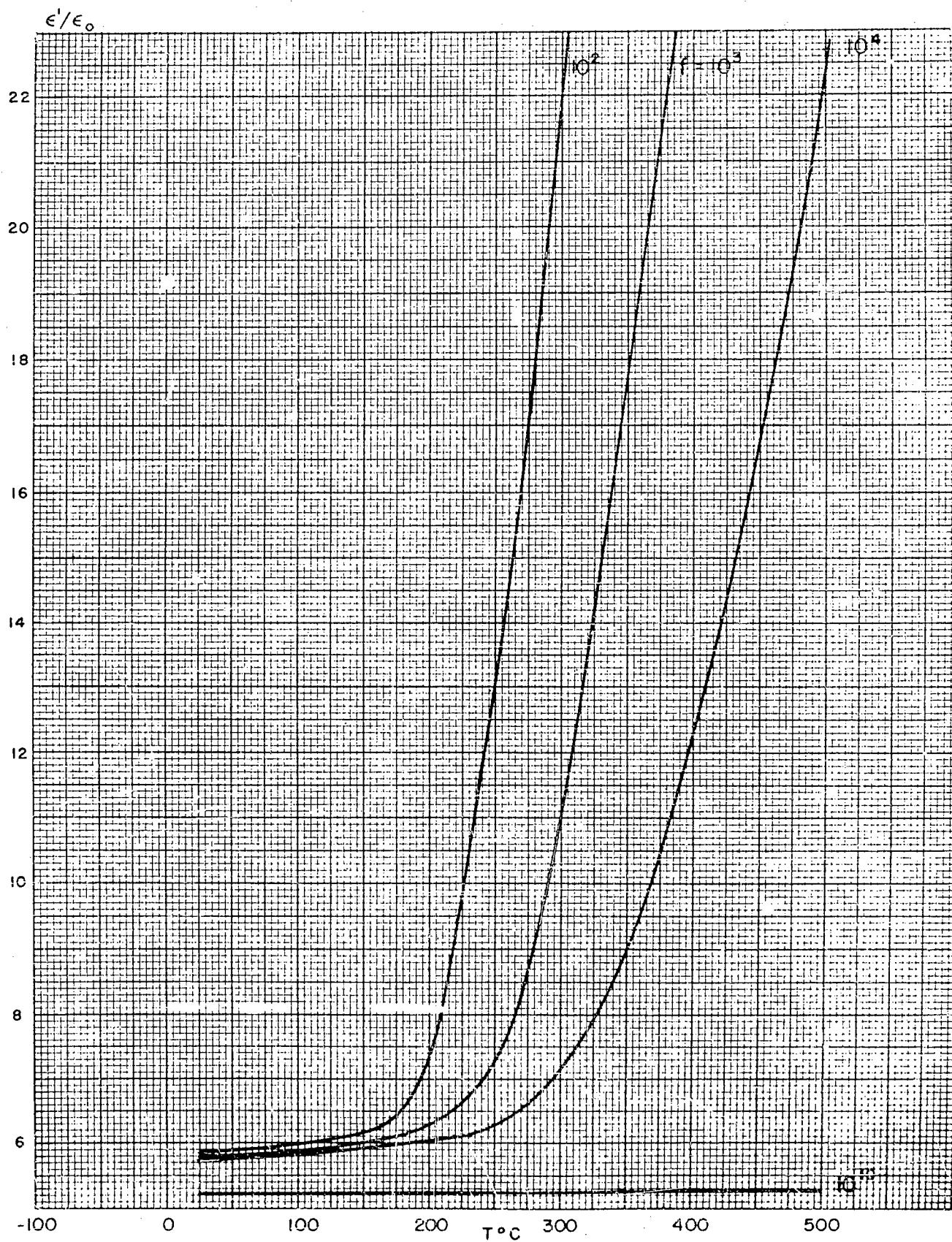


*Field \perp to optic axis and field \parallel to optic axis.

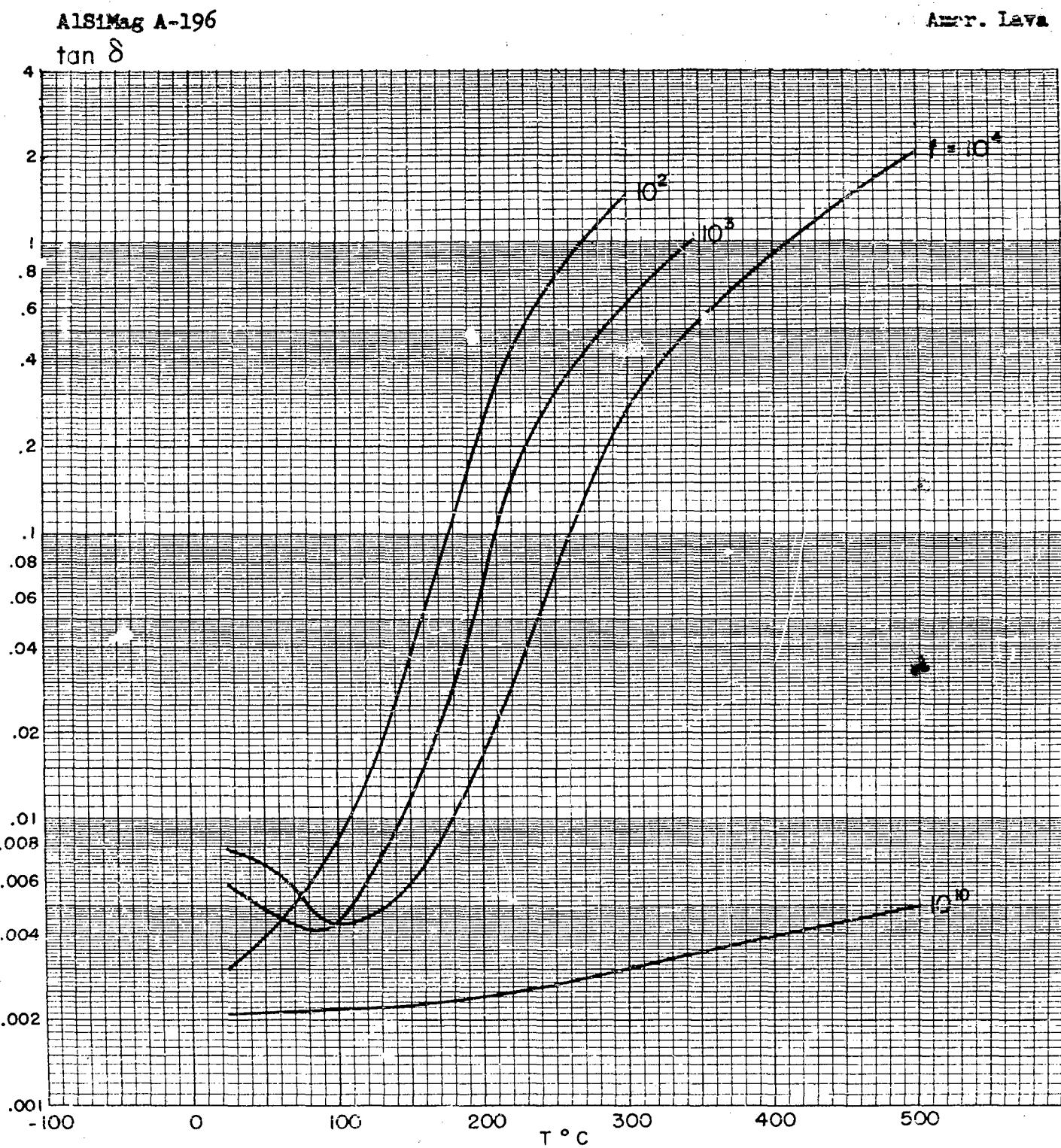
Steatite Bodies

AlSiMag A-196

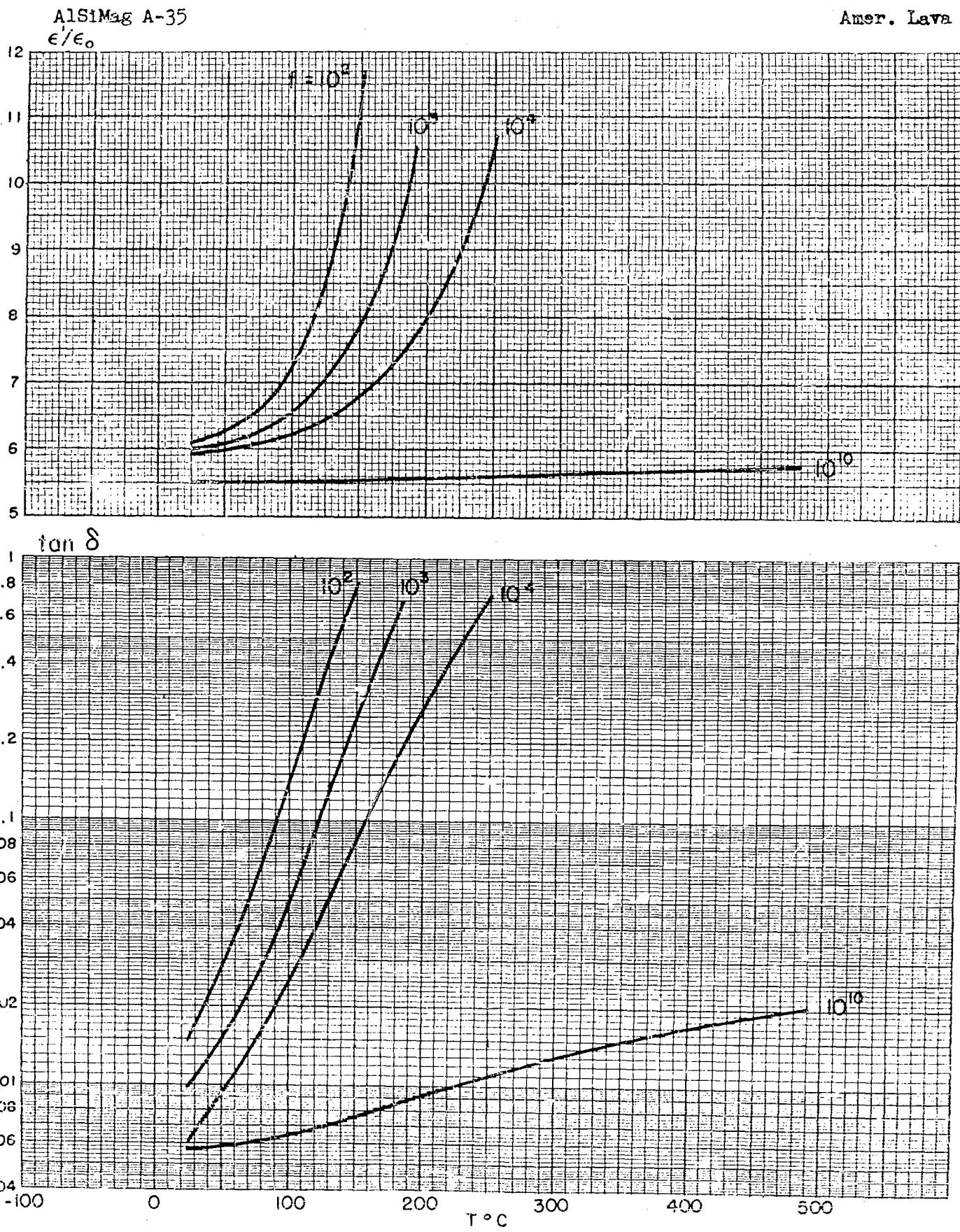
Amer. Lava



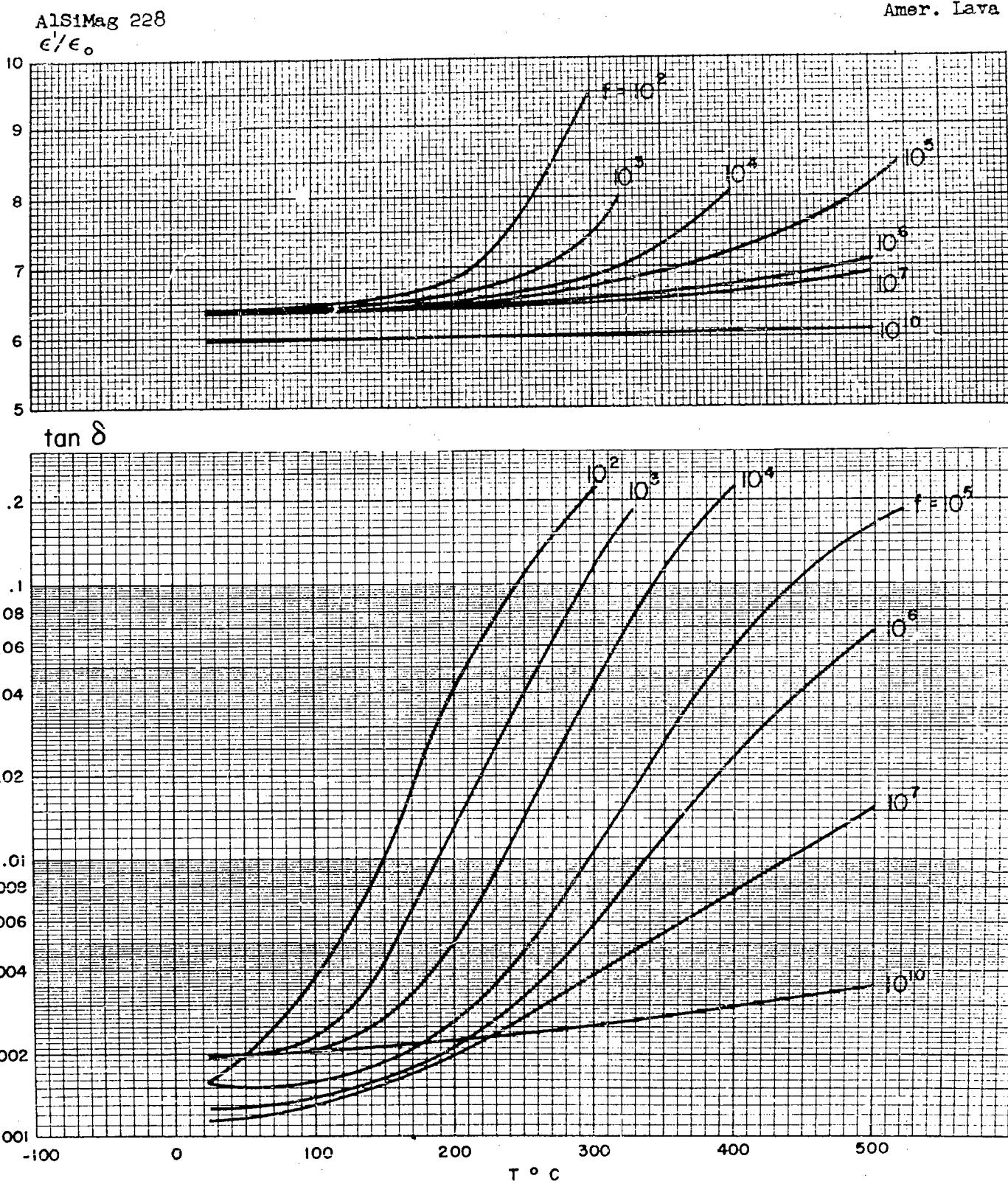
Steatite Bodies (cont.)



Steatite Bodies (cont.)



Steatite Bodies (cont.)

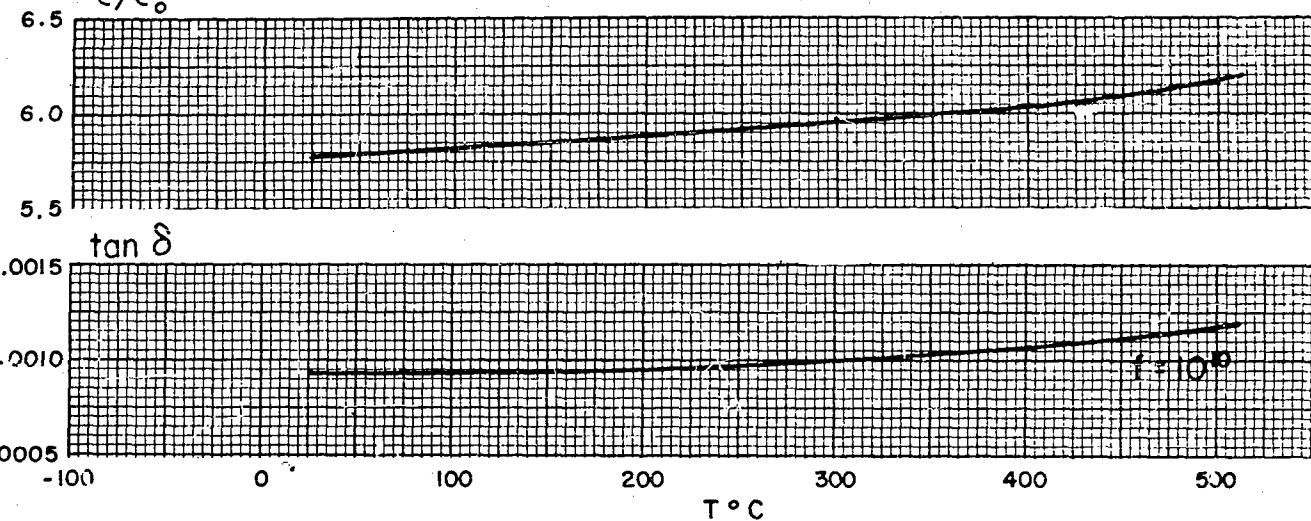


Steatite Bodies (cont.)

AlSiMag 243

Amer. Lava

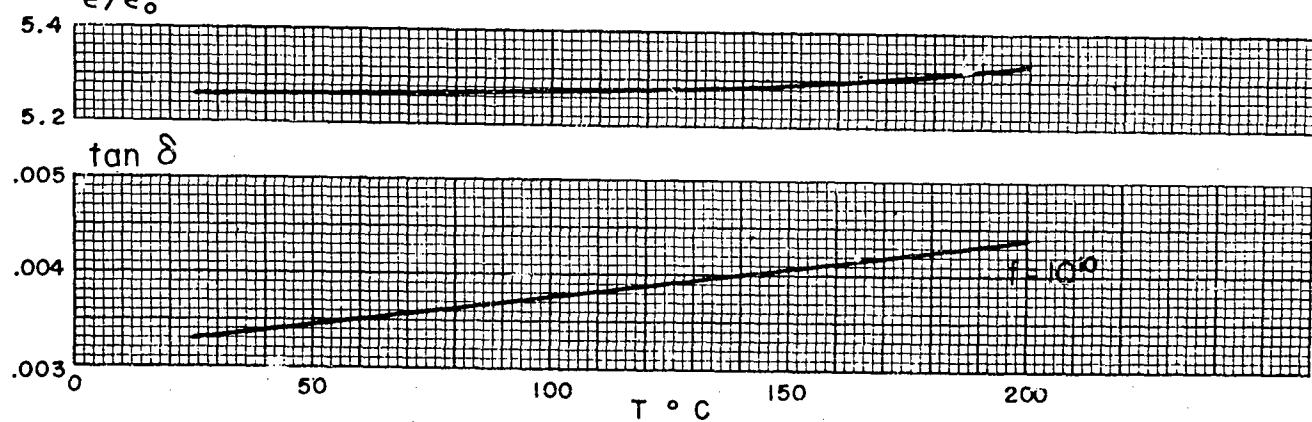
ϵ'/ϵ_0



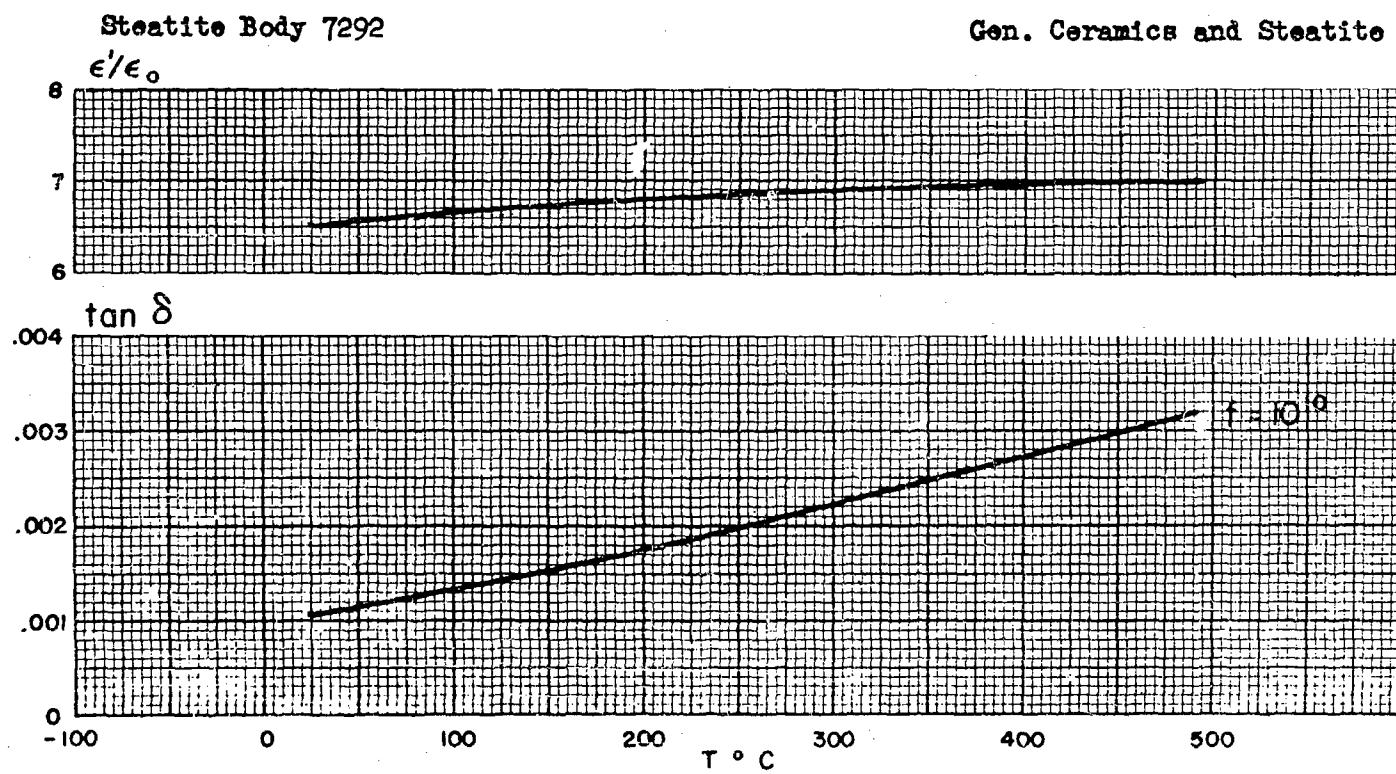
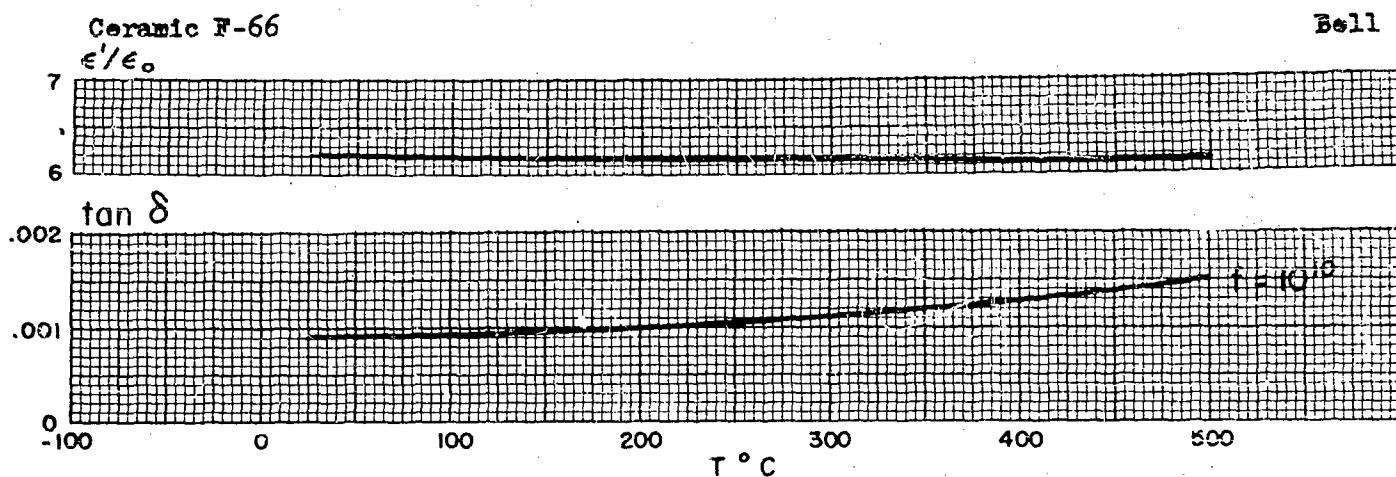
AlSiMag 505

Amer. Lava

ϵ'/ϵ_0



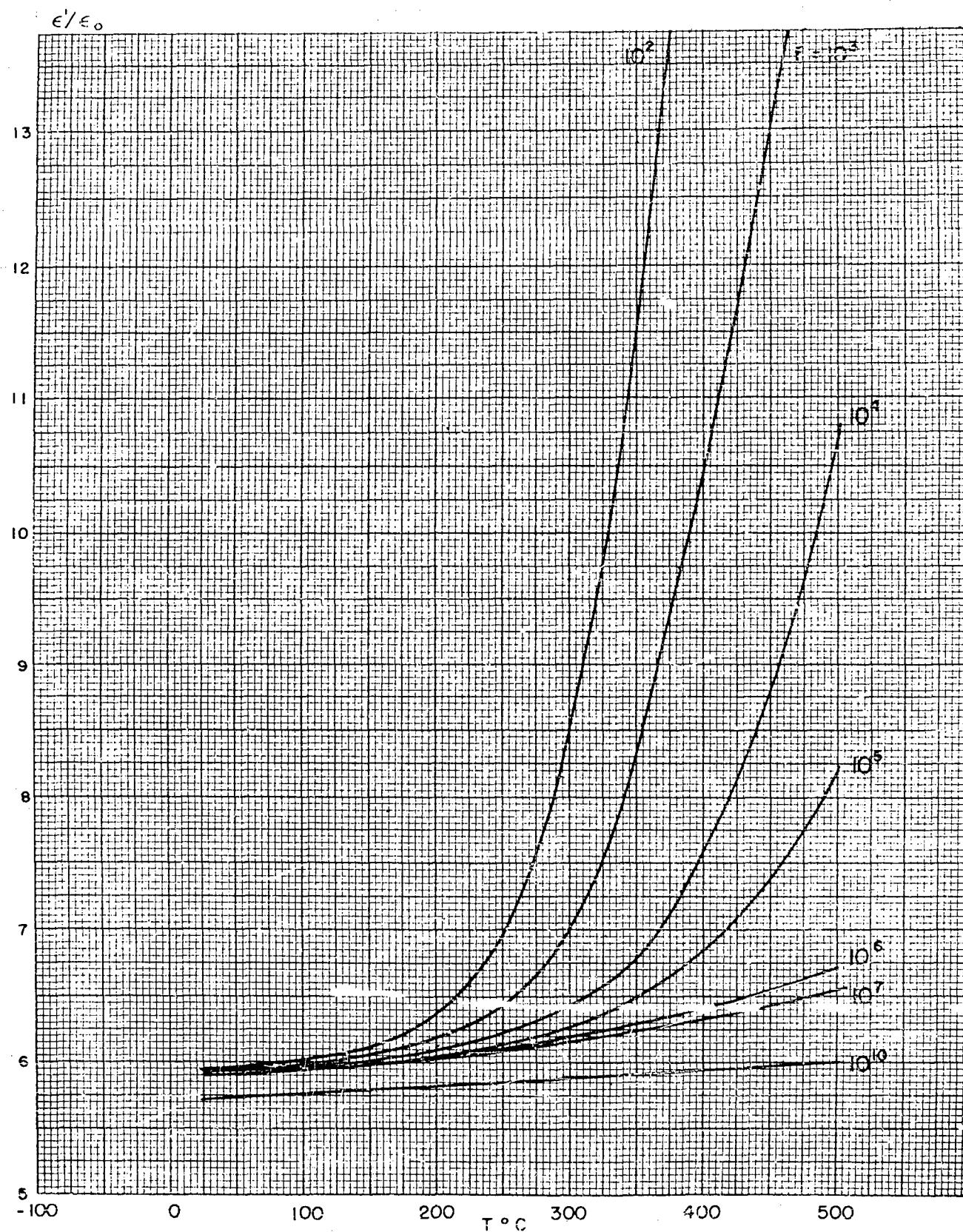
Steatite Bodies (cont.)



Steatite Bodies (cont.)

Steatite Type 302

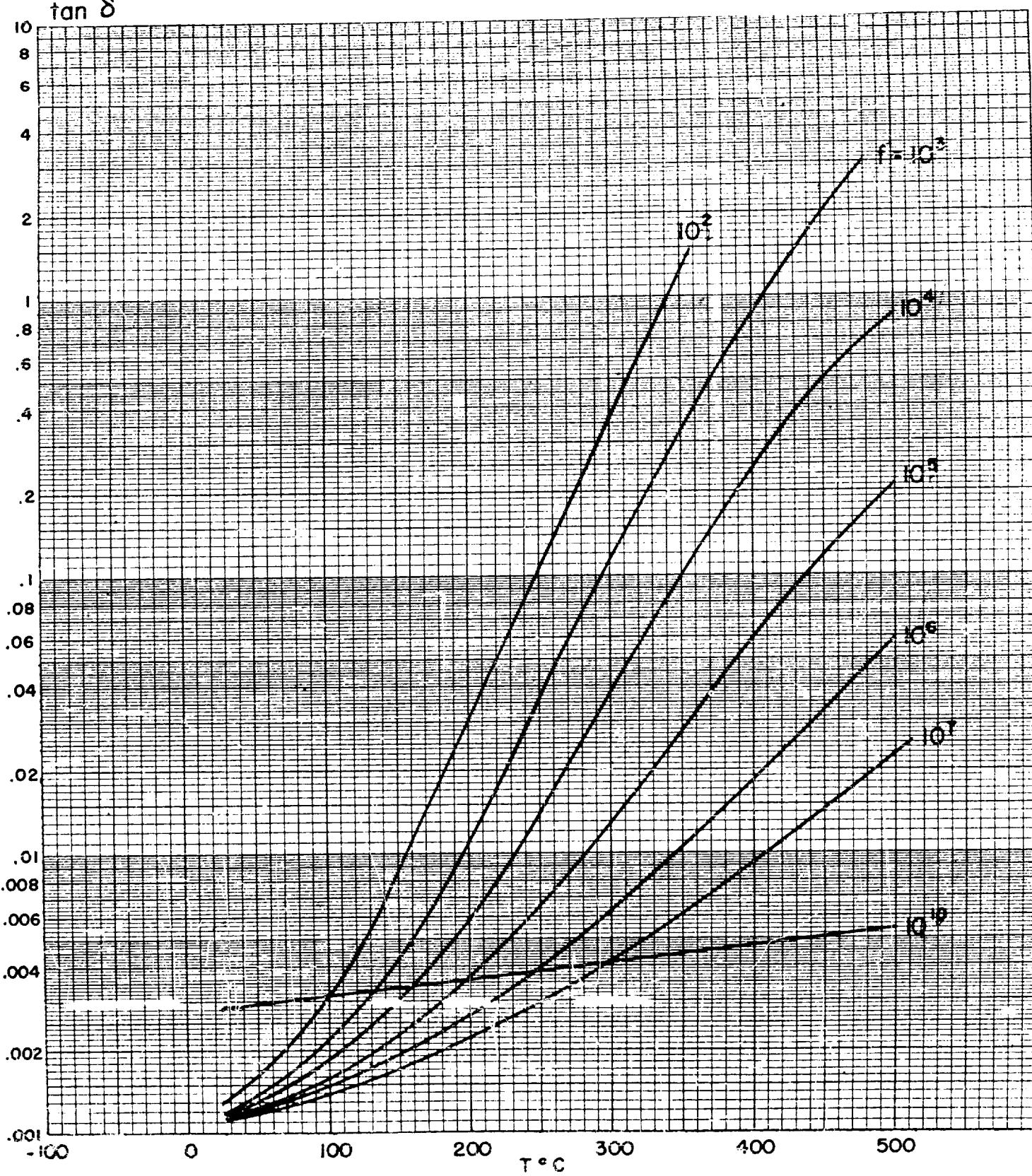
Centralab



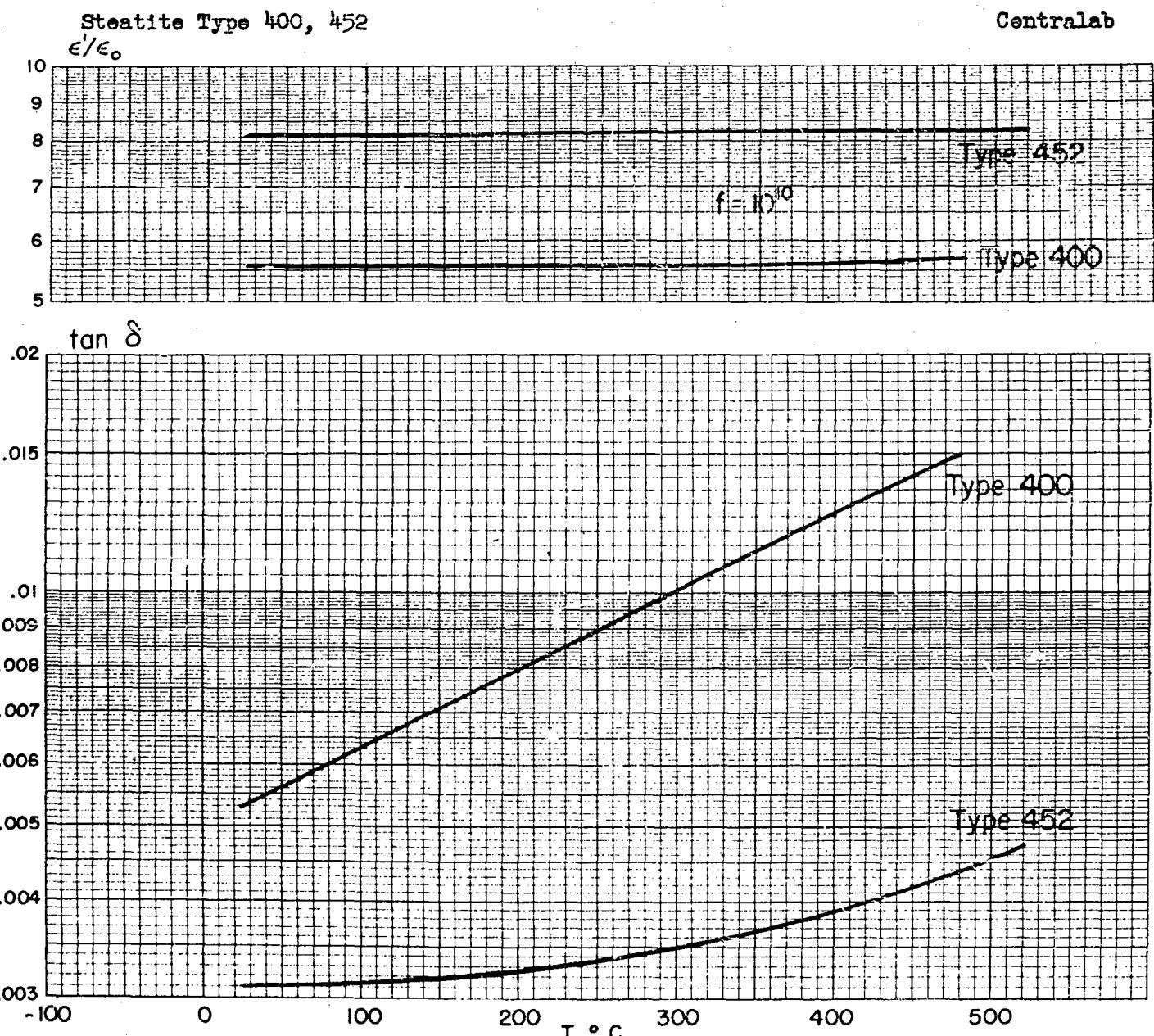
Steatite Bodies (cont.)

Centralab

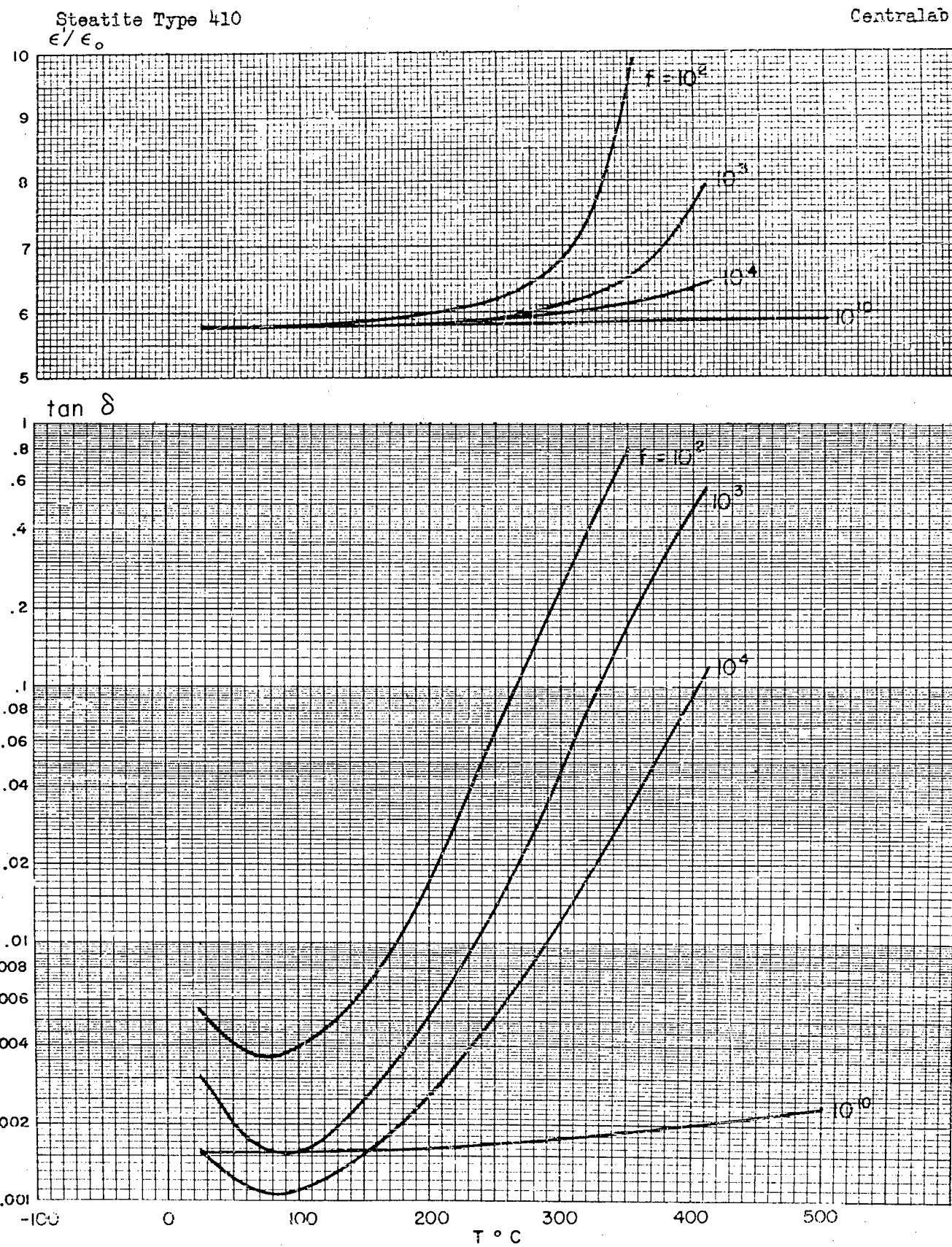
Steatite Type 302
 $\tan \delta$



Steatite Bodies (cont.)



Steatite Bodies (cont.)

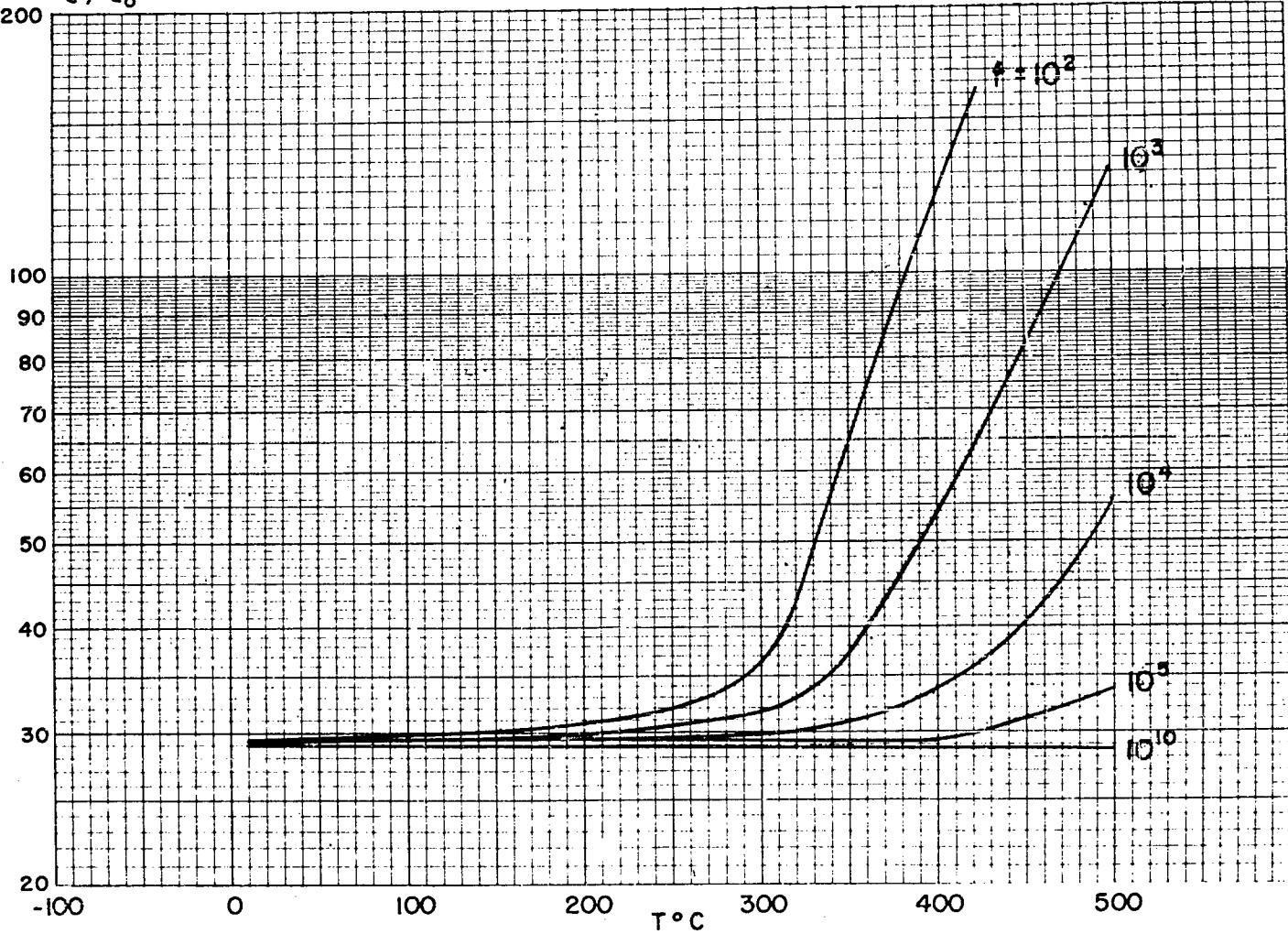


Titania and Titanate Bodies

Ceramic NPOT 96

Amer. Lava

ϵ' / ϵ_0

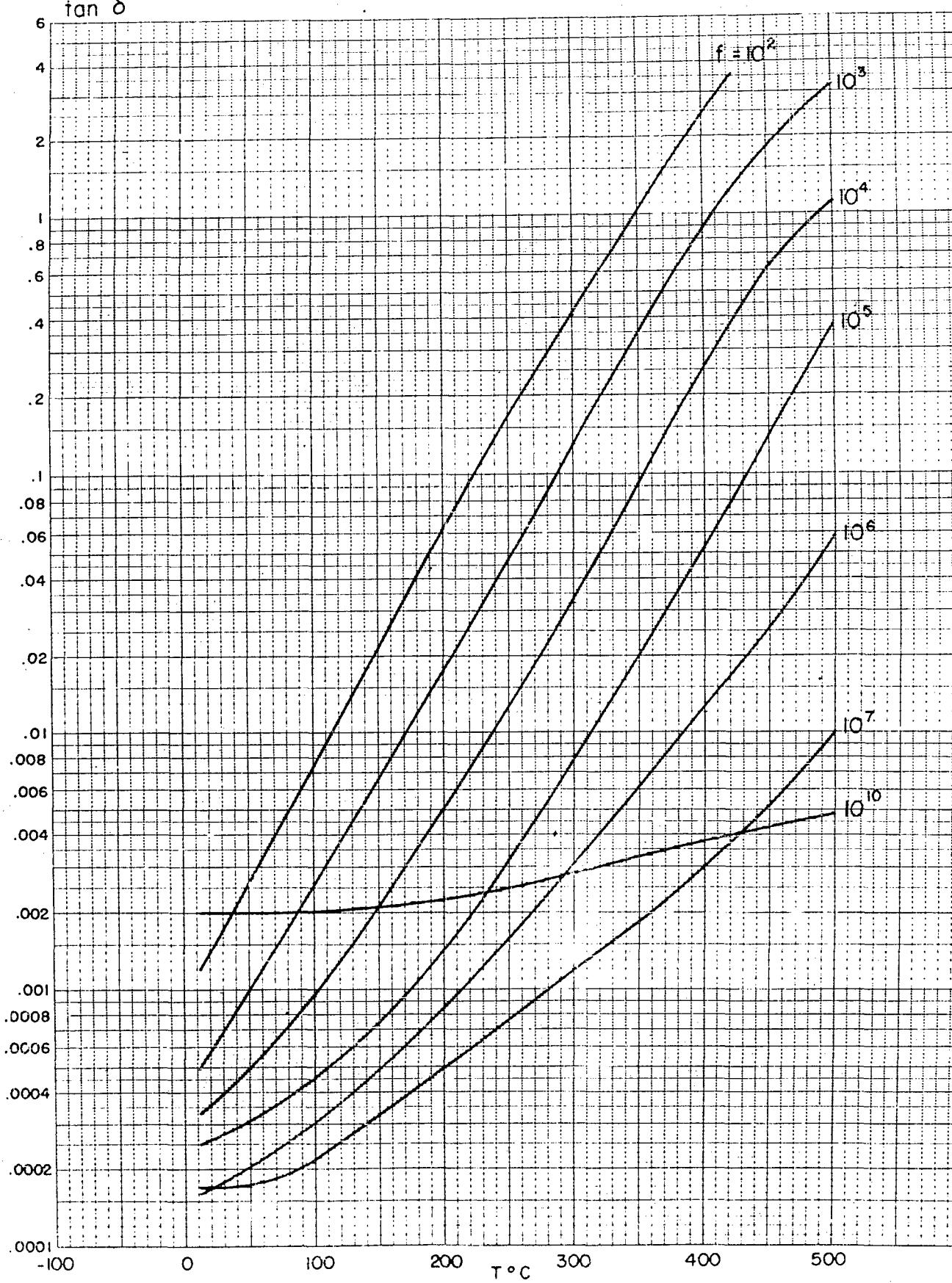


Titania and Titanate Bodies (cont.)

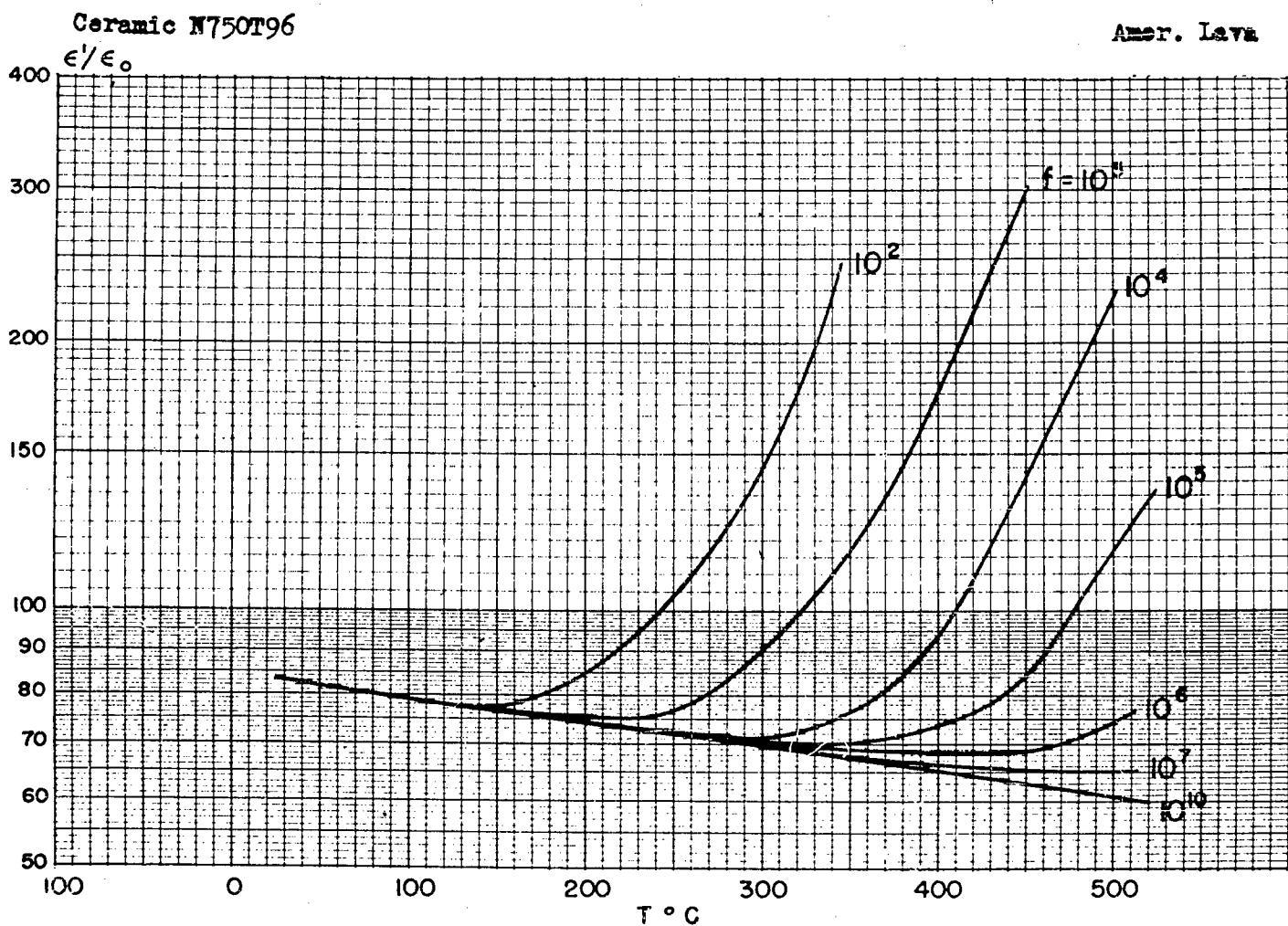
Ceramic NPOT 96

$\tan \delta$

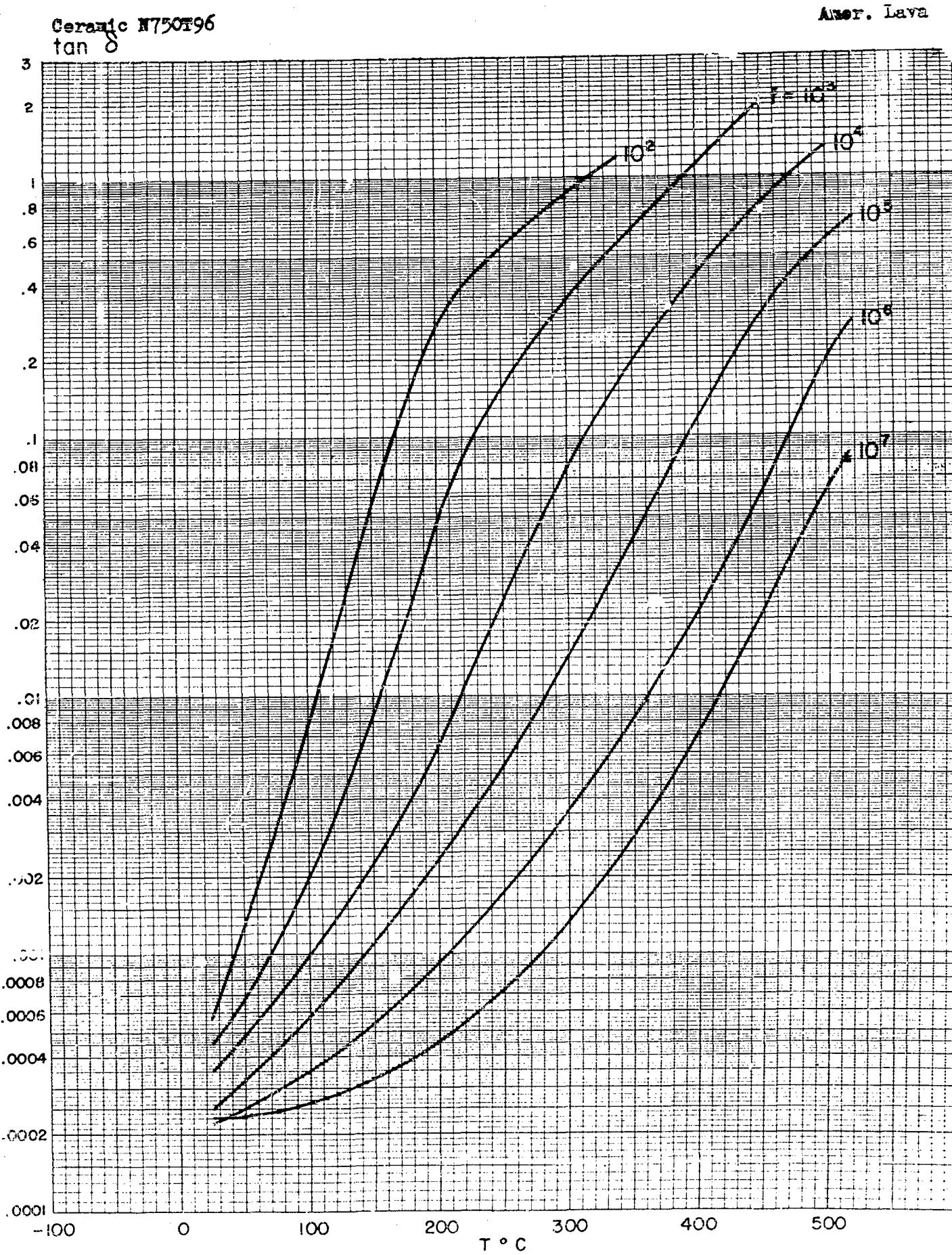
Amer. Lava



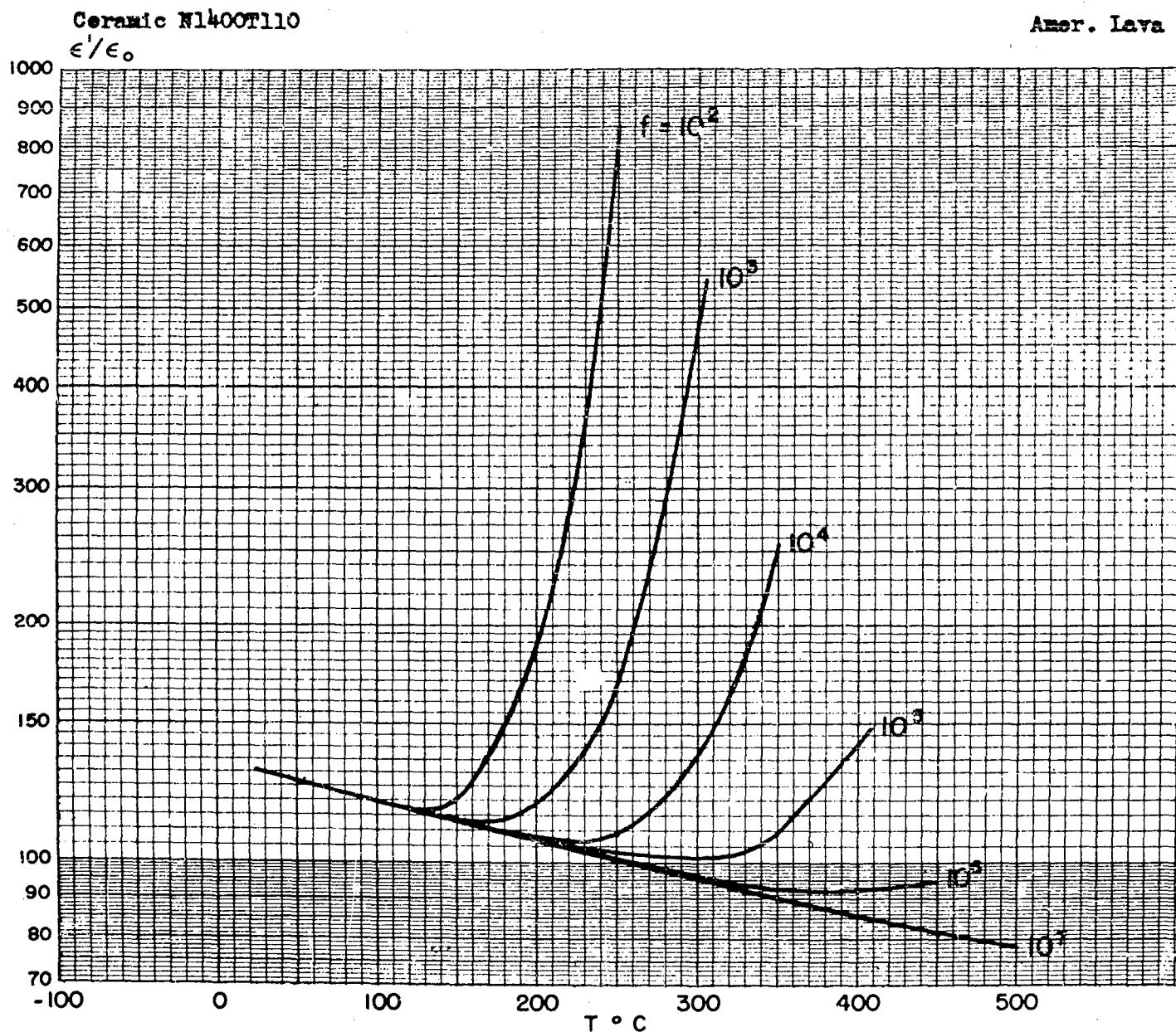
Titania and Titanate Bodies (cont.)



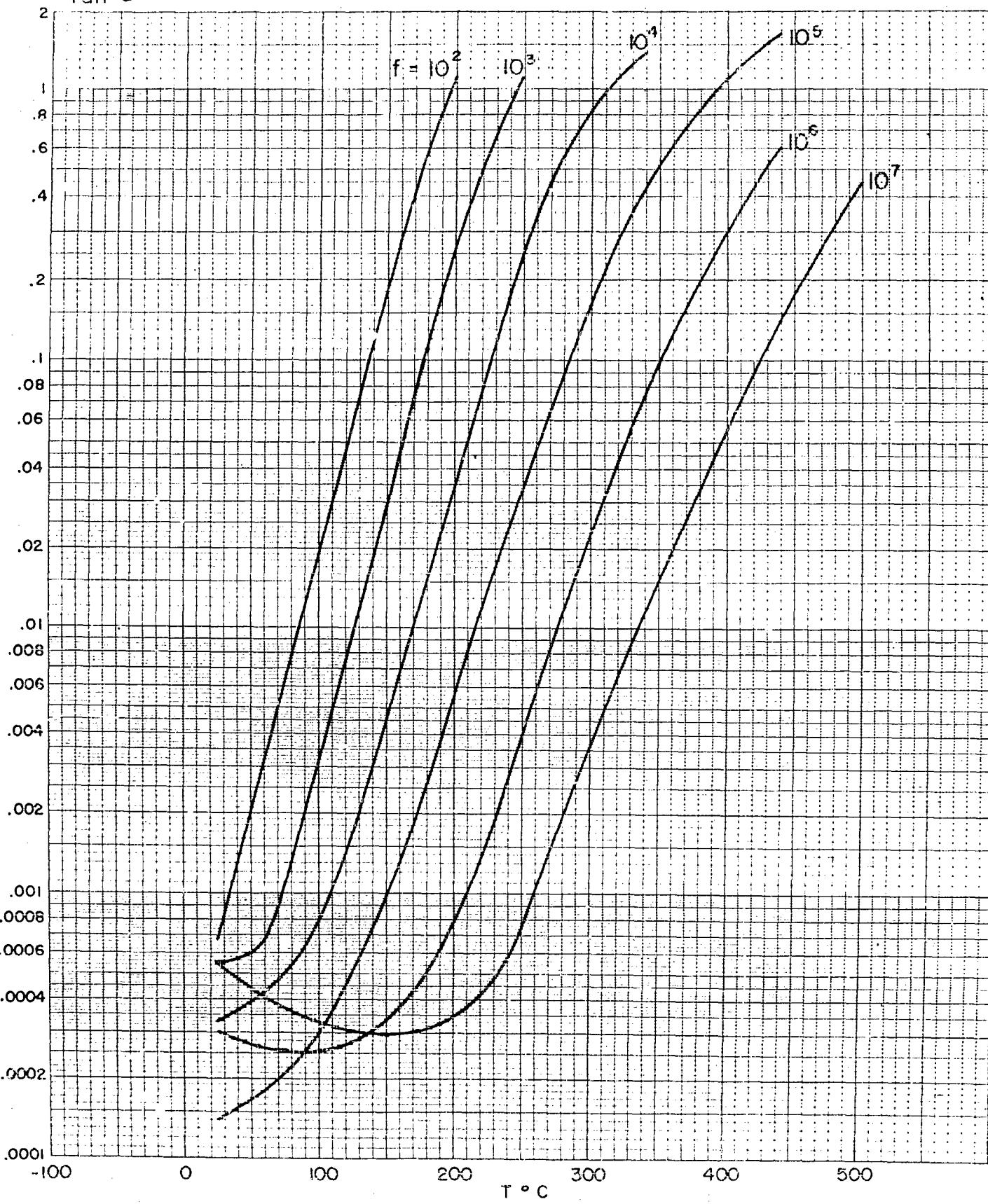
Titania and Titanate Bodies (cont.)



Titania and Titanate Bodies (cont.)



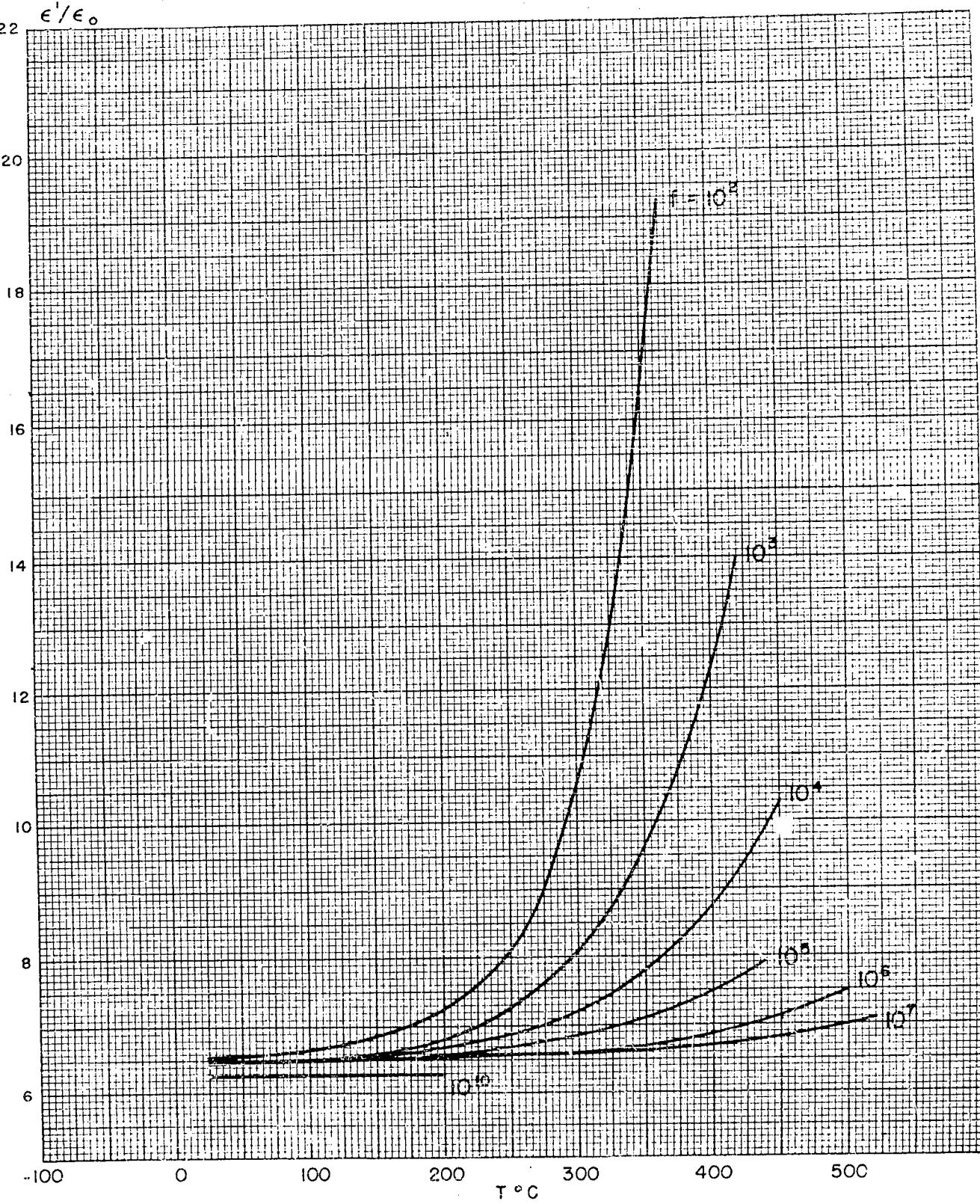
Titania and Titanate Bodies (cont.)



Porcelains

Coors

Zirconium porcelain Z1-4
 ϵ'/ϵ_0

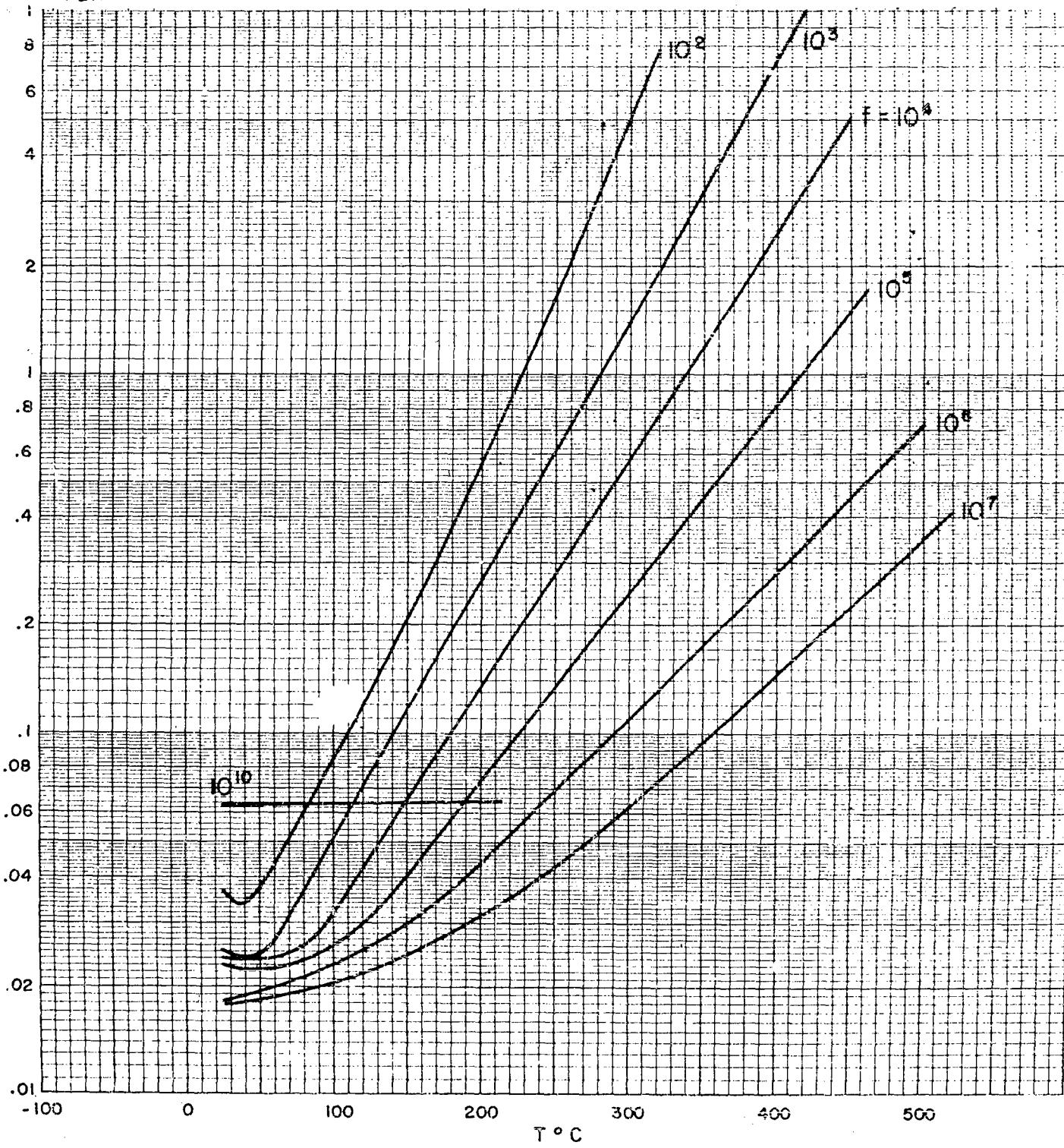


Porcelains (cont.)

Zirconium porcelain Zi-4

Coors

$\tan \delta$

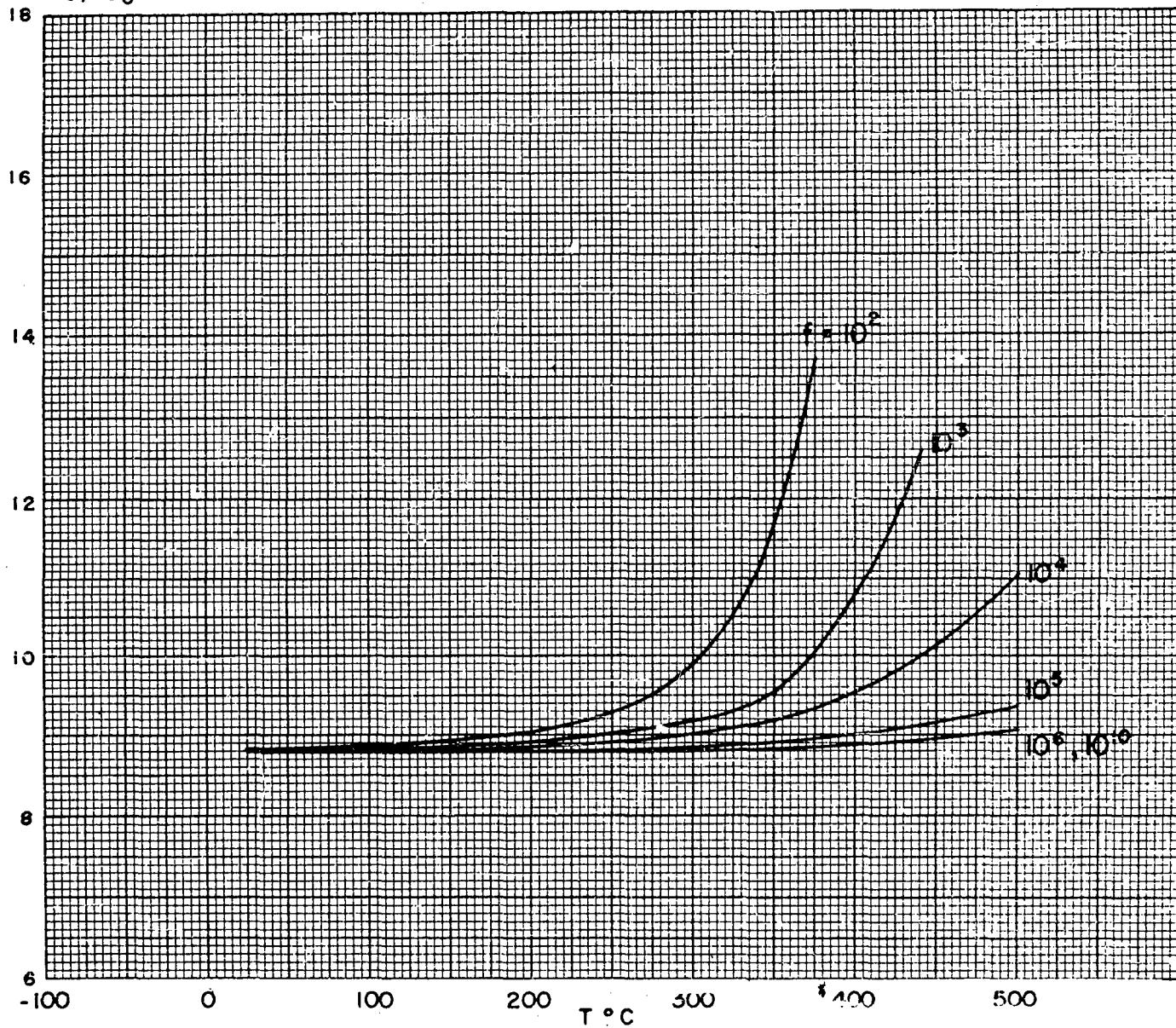


Porcelains (cont.)

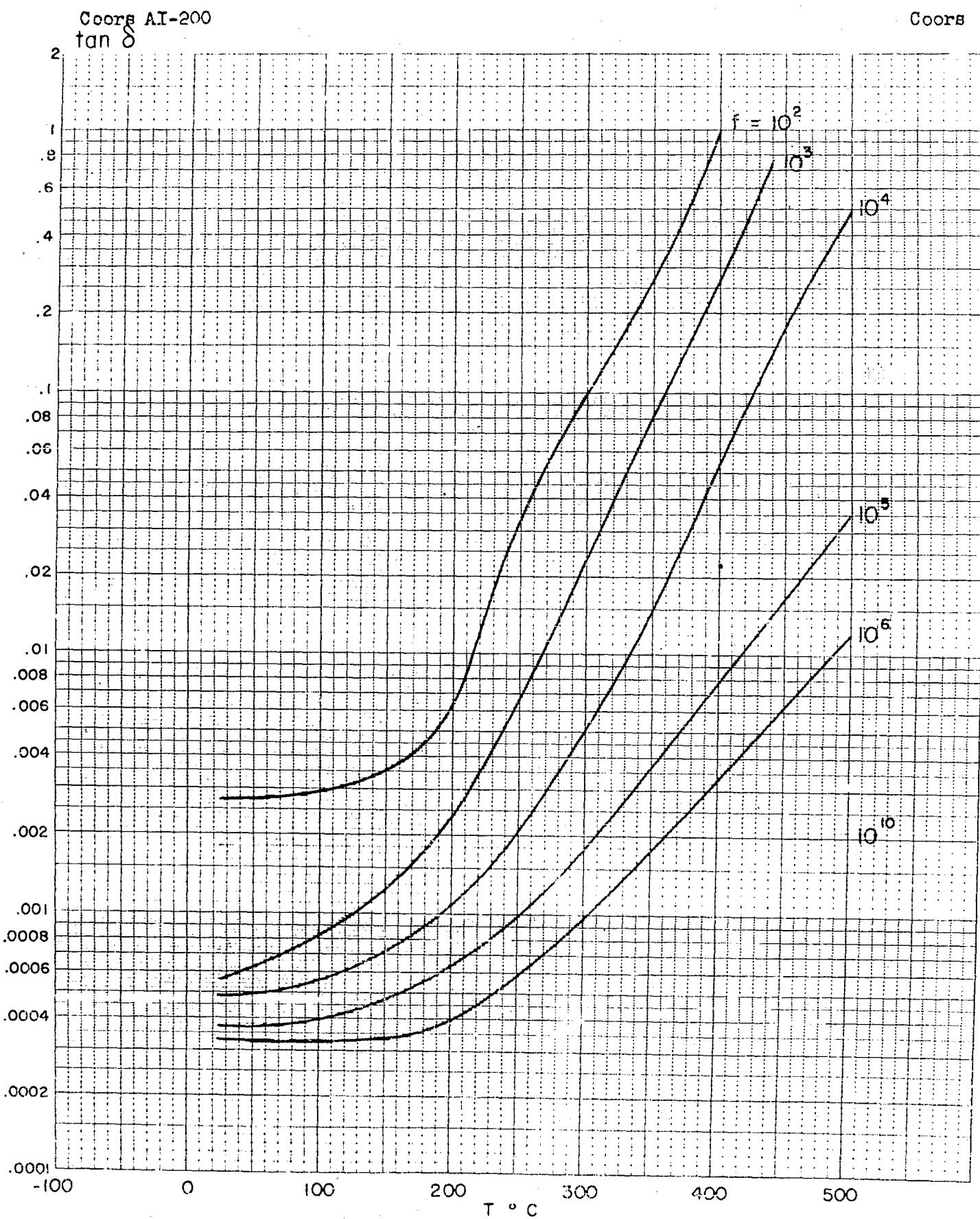
Coors Al-200

Coors

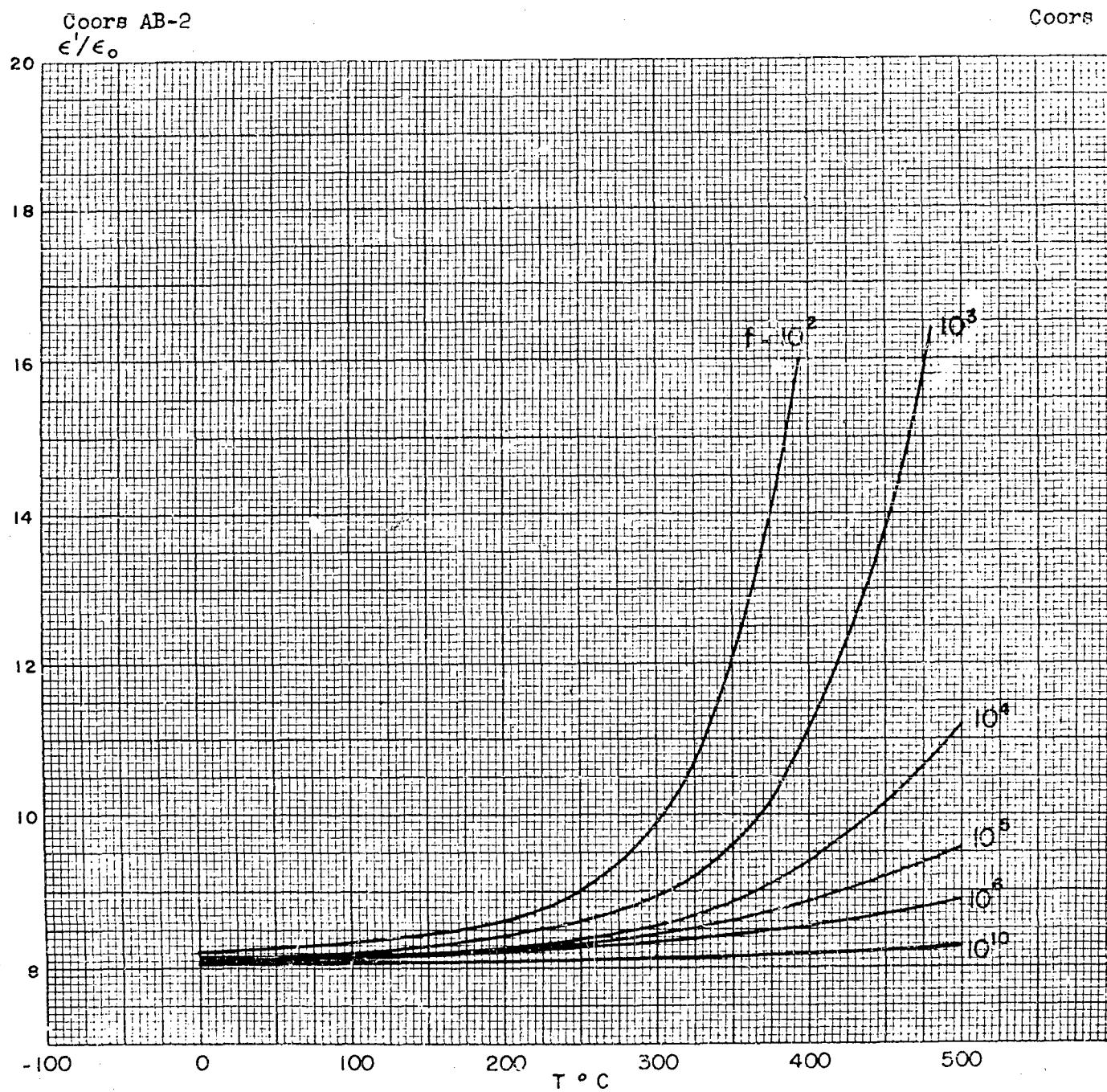
ϵ'/ϵ_0



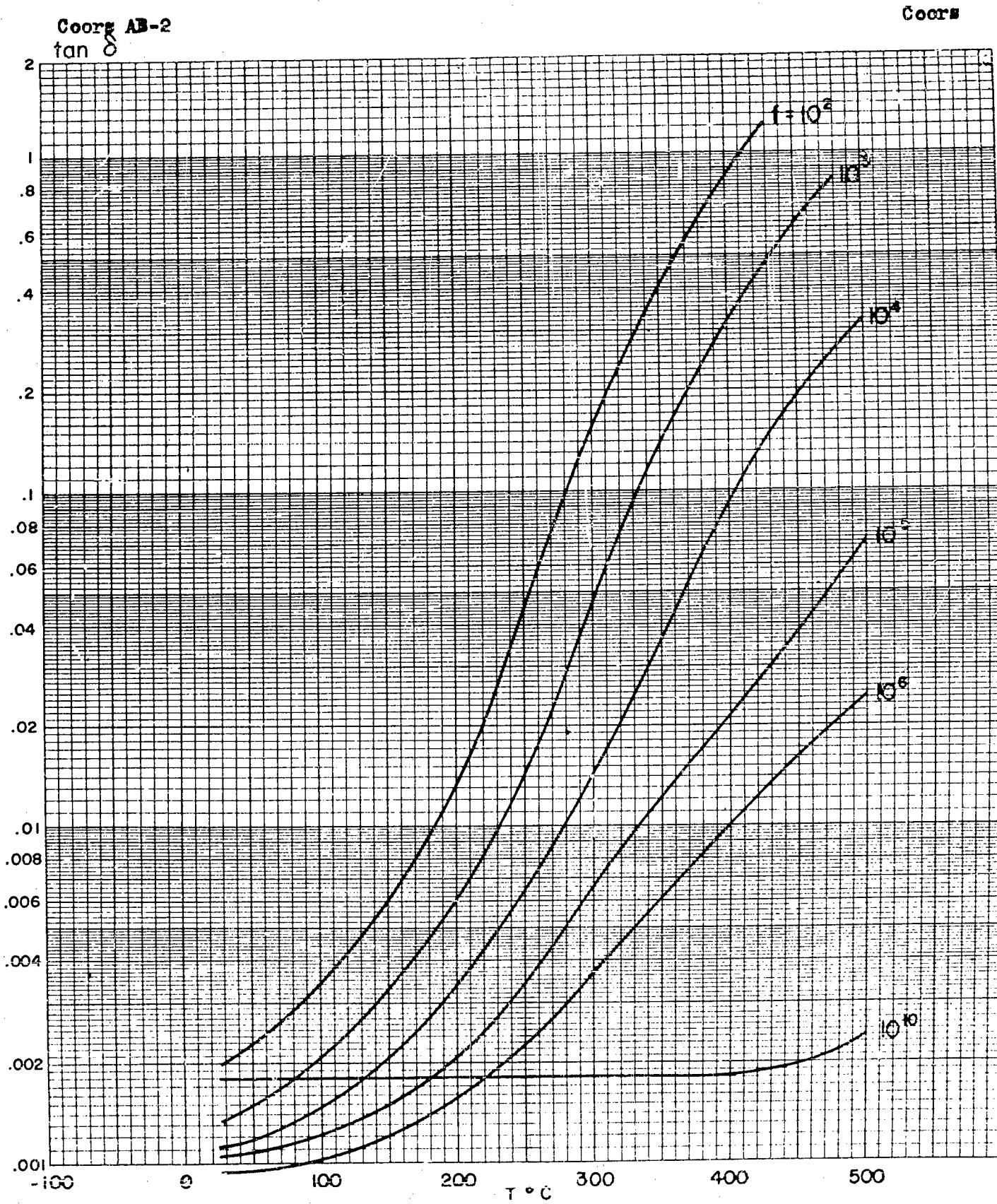
Porcelains (cont.)



Porcelains (cont.)



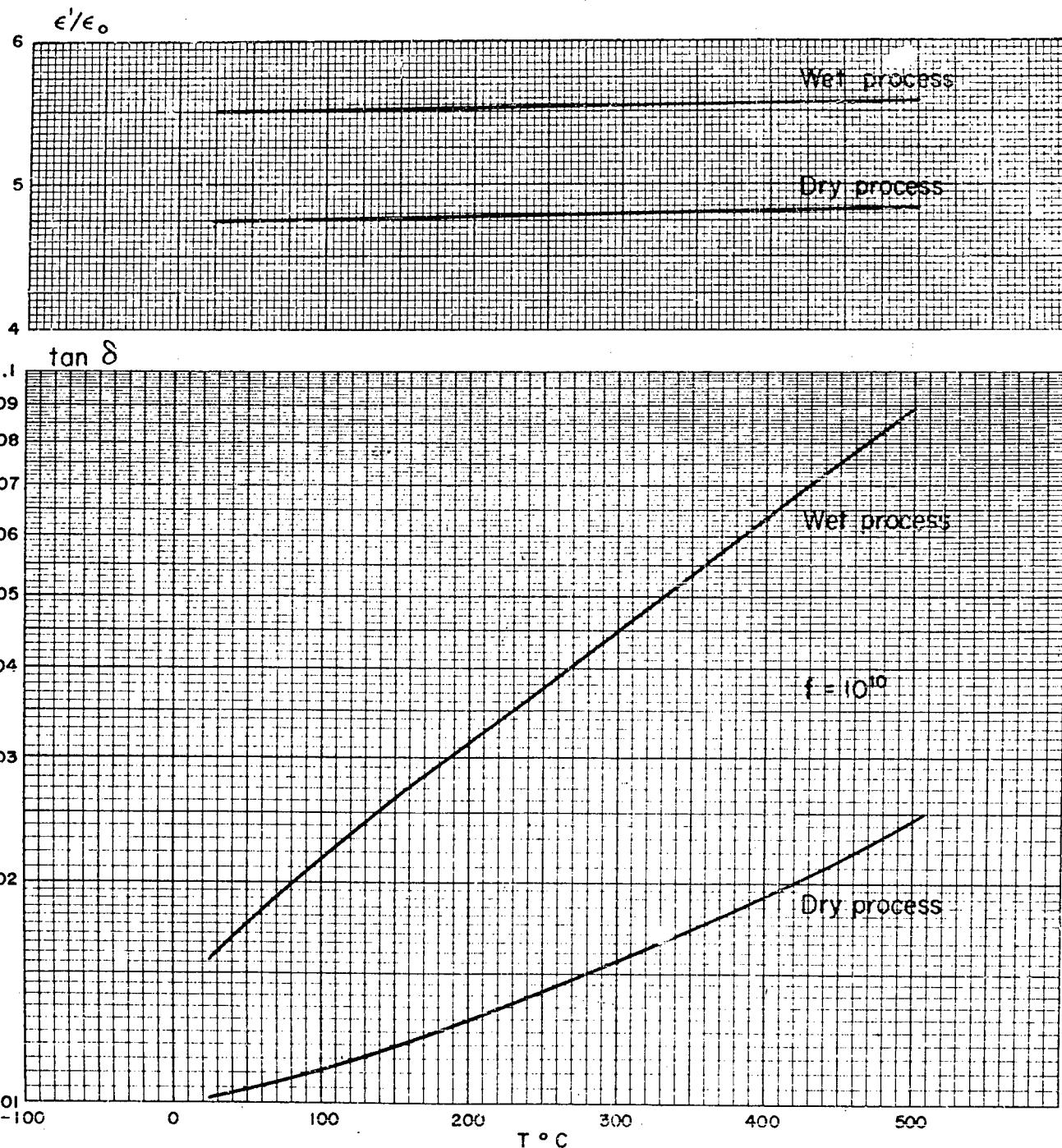
Porcelains (cont.)



Porcelains (cont.)

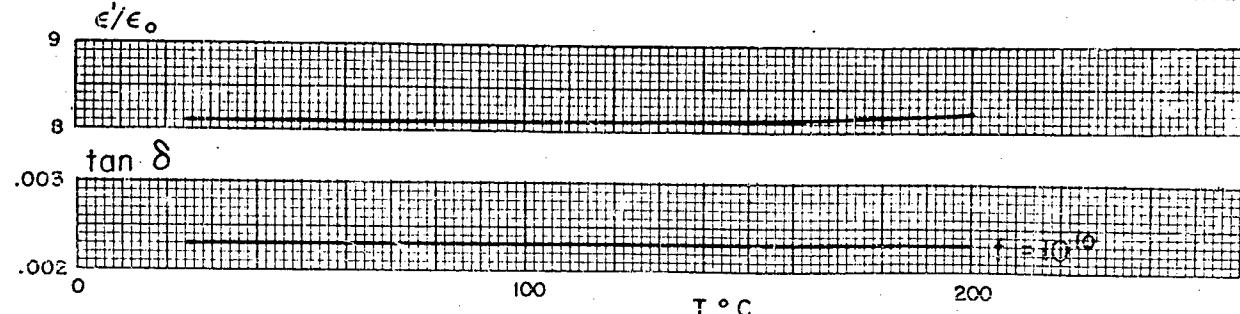
Porcelain, wet process; dry process

Knox



AlSiMag 491

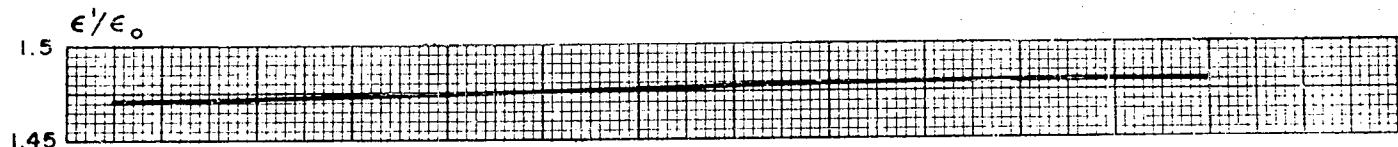
Amer. Lava



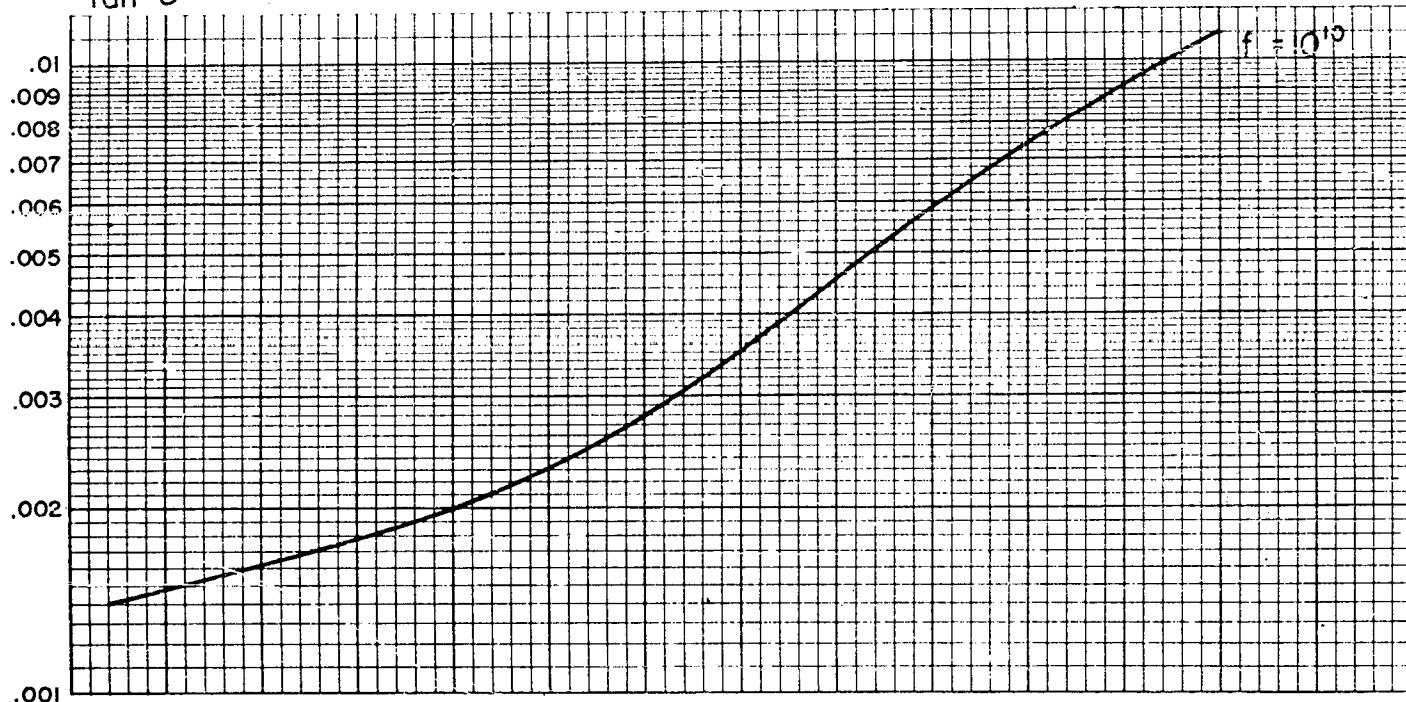
Miscellaneous Ceramics

Porous Ceramic AF-497

Stupakoff



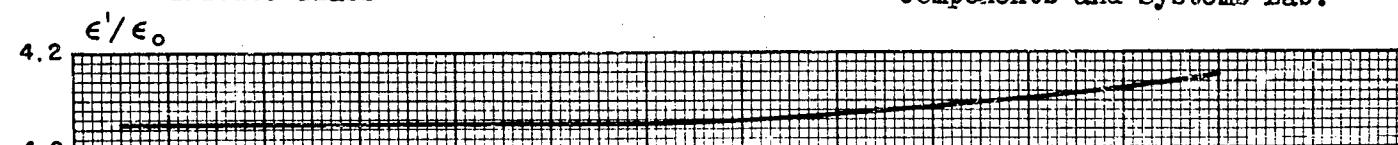
$\tan \delta$



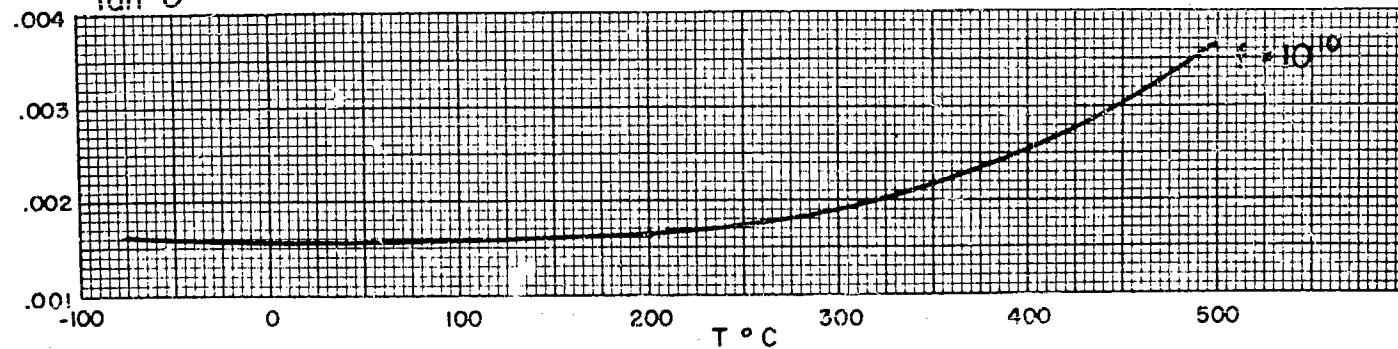
Glasses

Borosilicate Glass

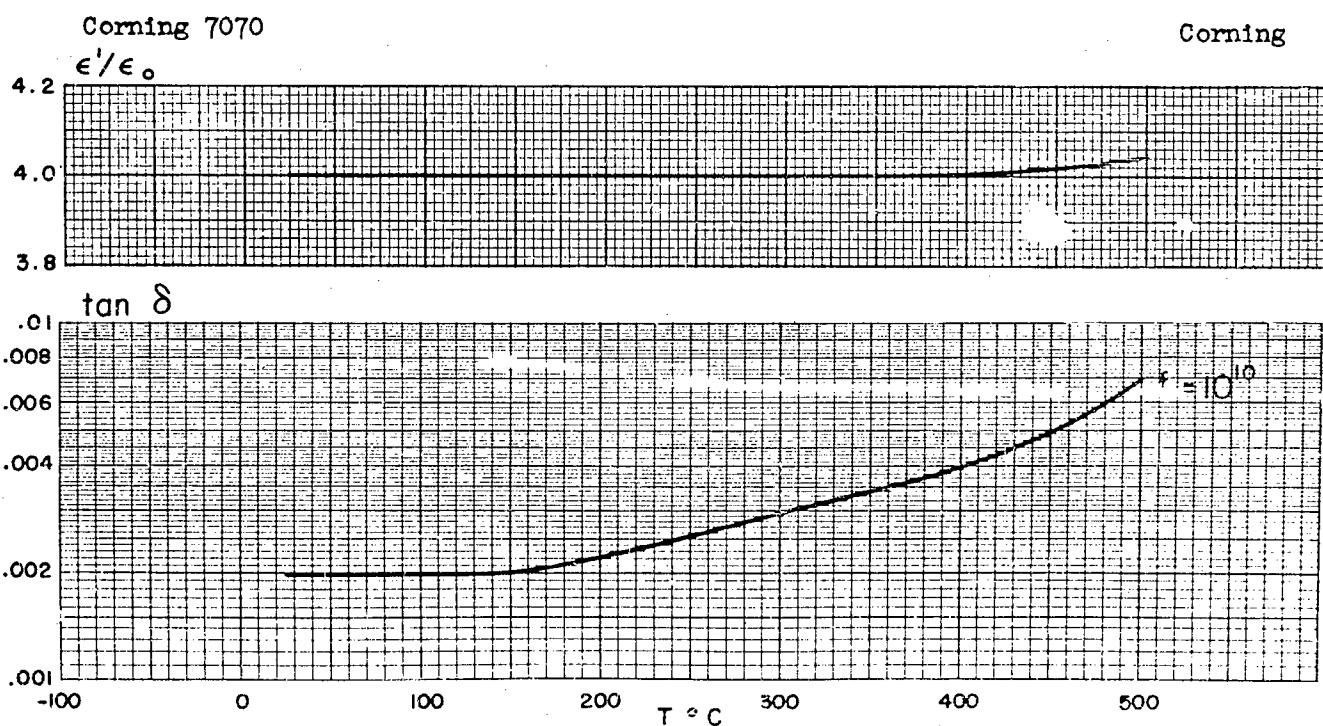
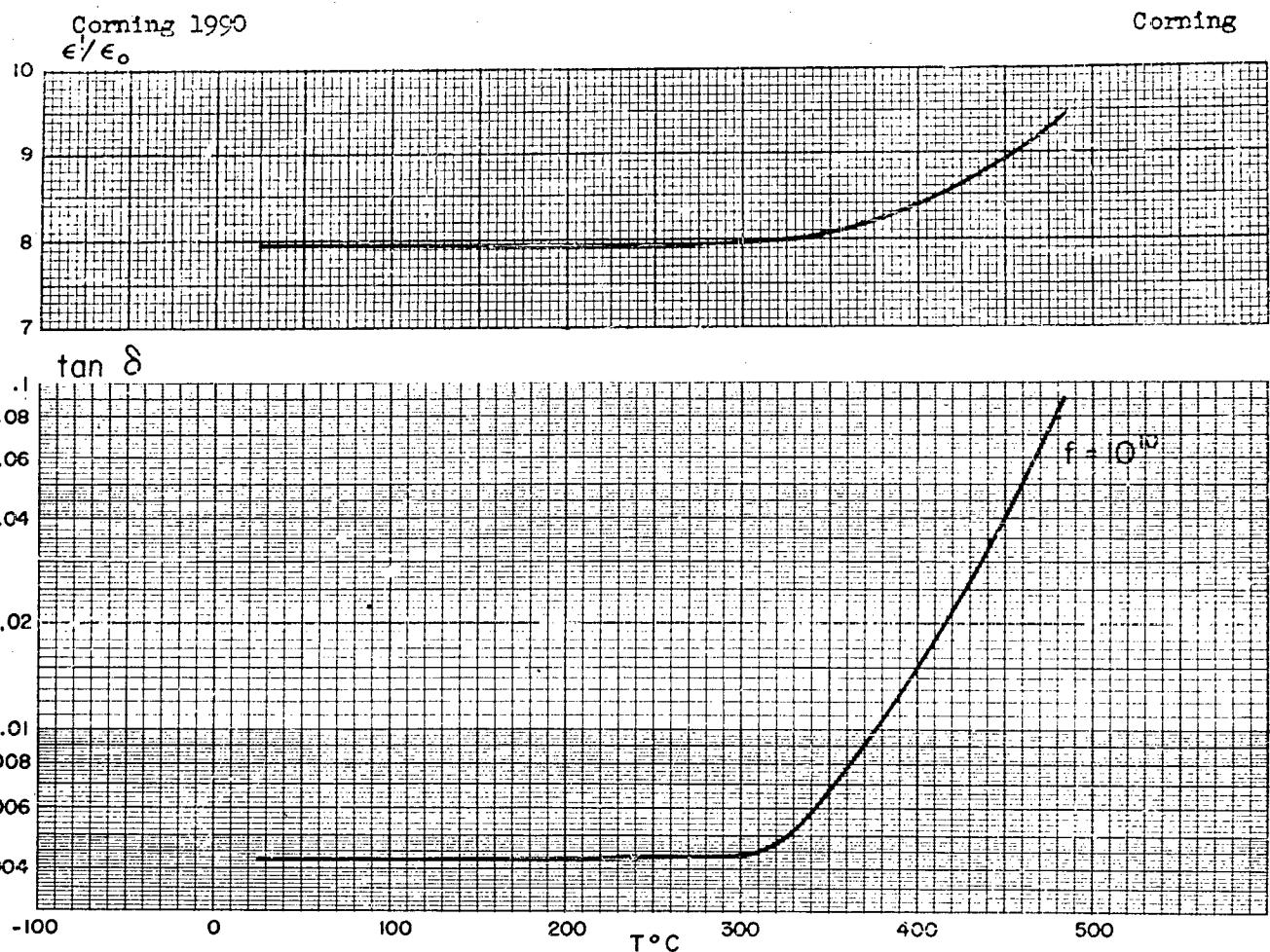
Components and Systems Lab.



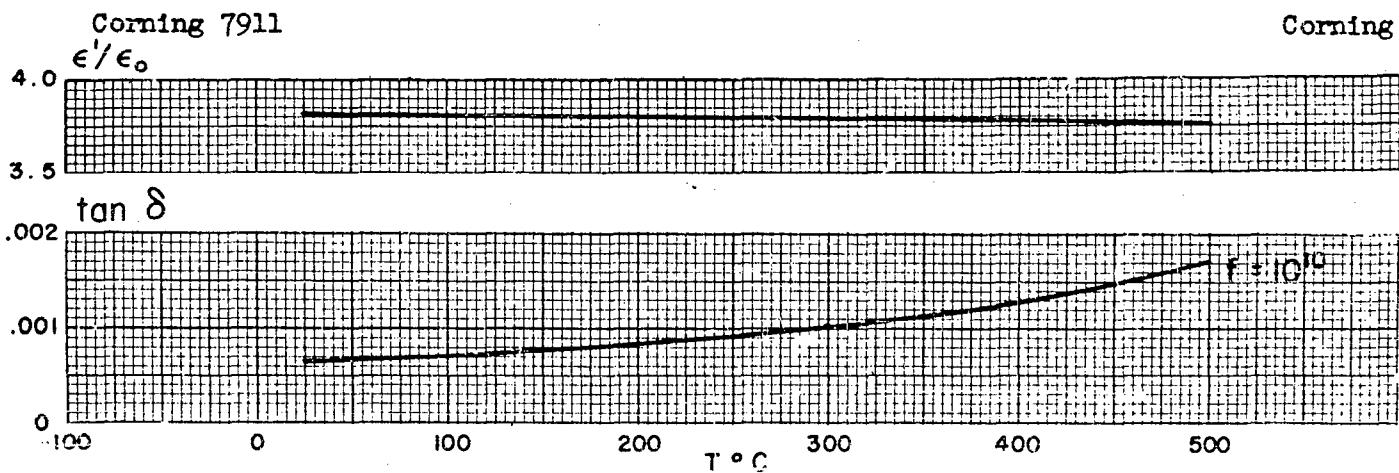
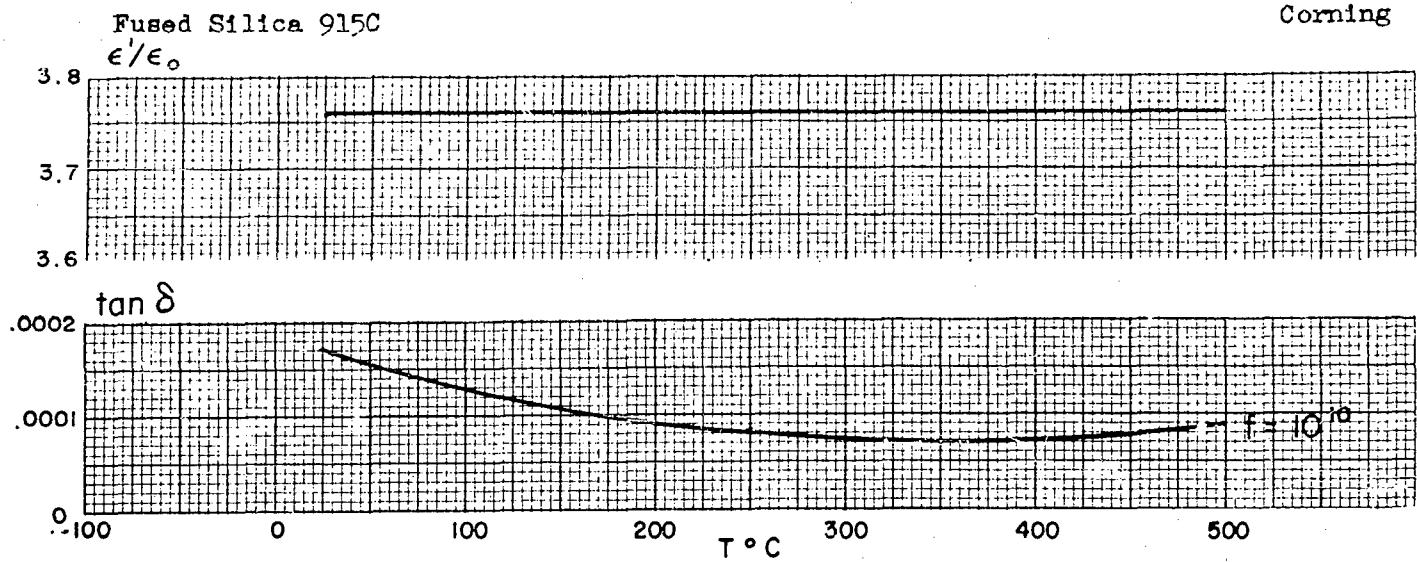
$\tan \delta$



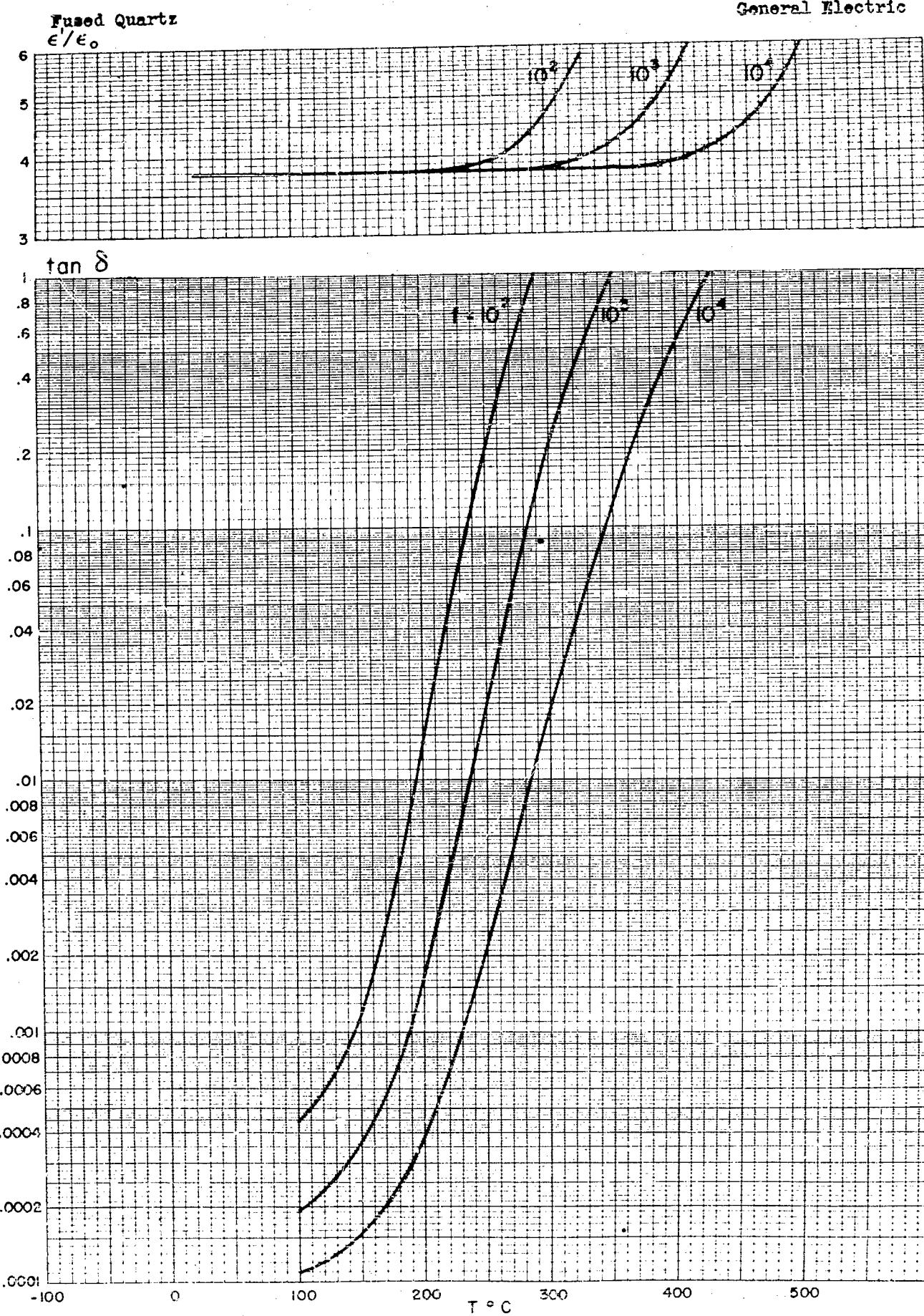
Glasses (cont.)



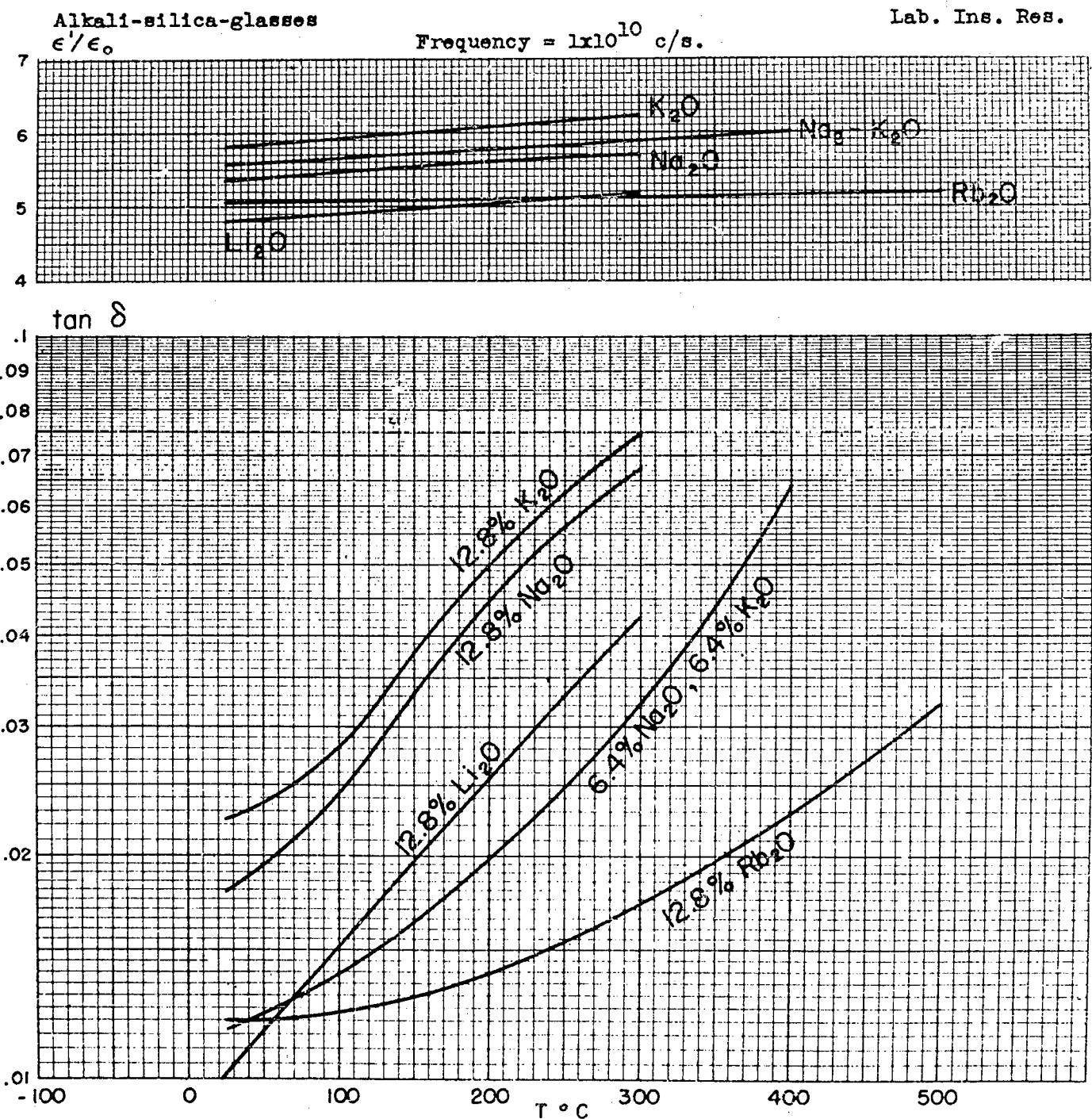
Glasses (cont.)



Glasses (cont.)



Glasses (cont.)

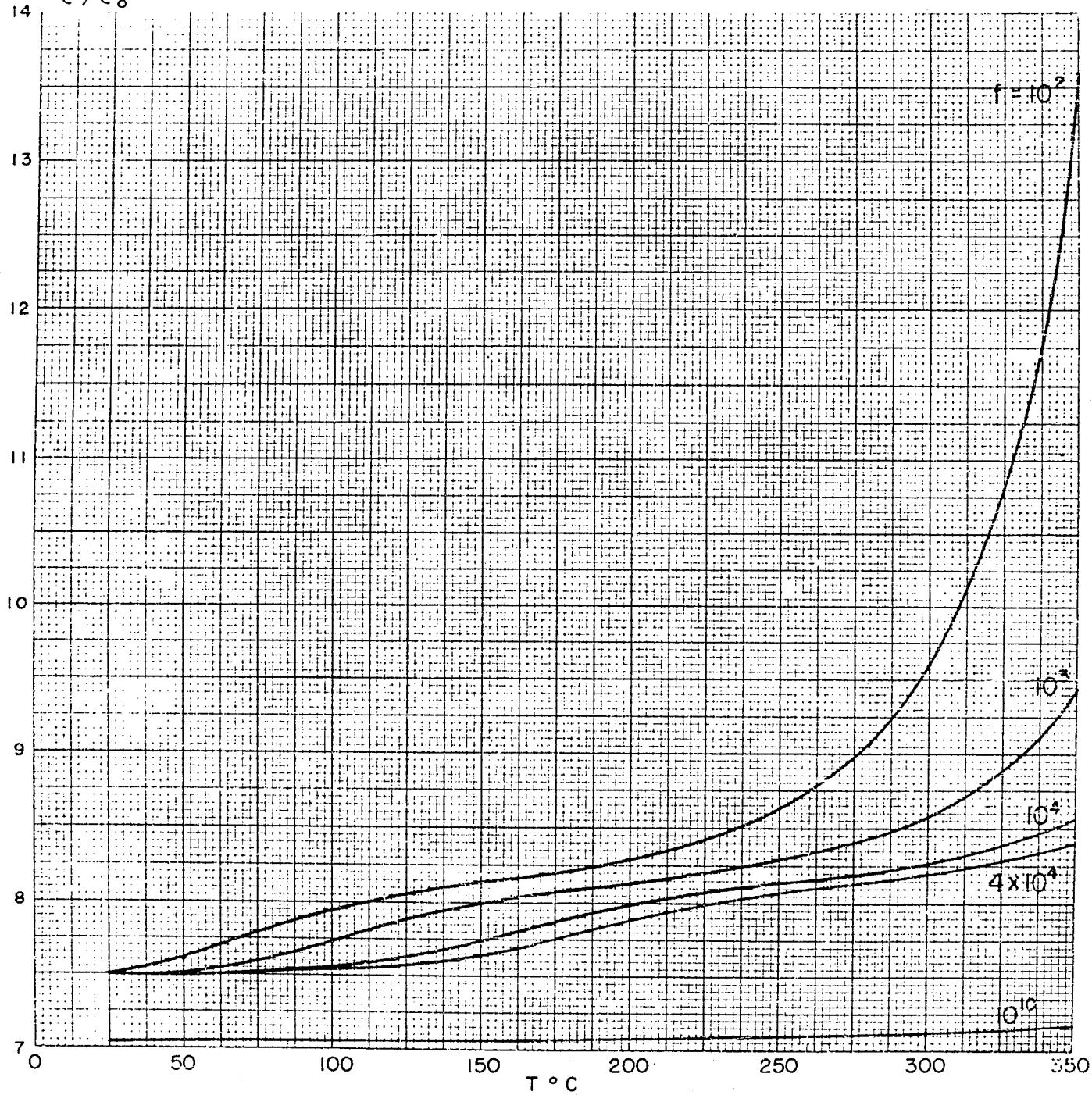


Mica and Glass

Mycalex 2821

General Electric

ϵ'/ϵ_0

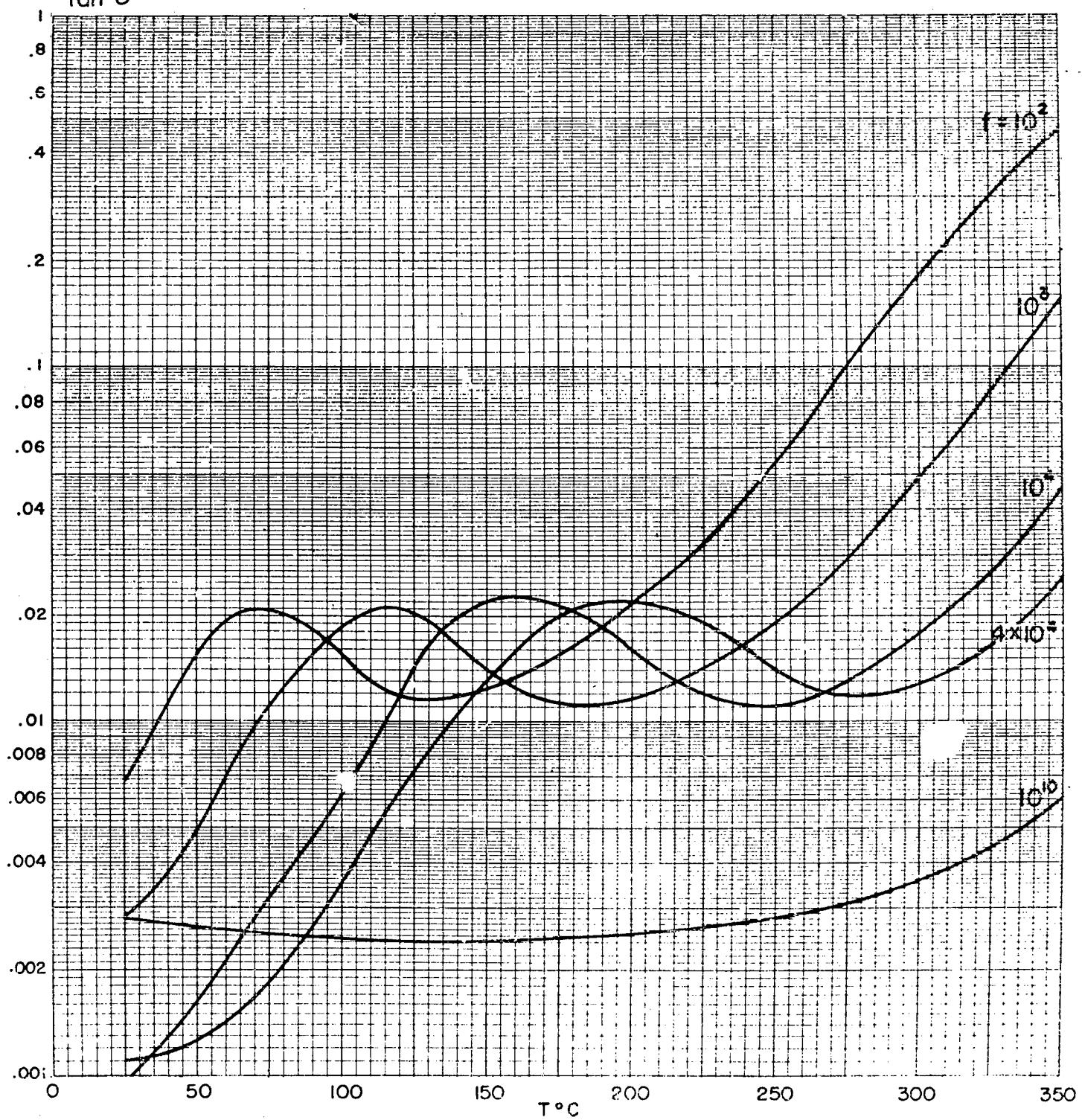


Mica and Glass (cont.)

Mycalex 2821

$\tan \delta$

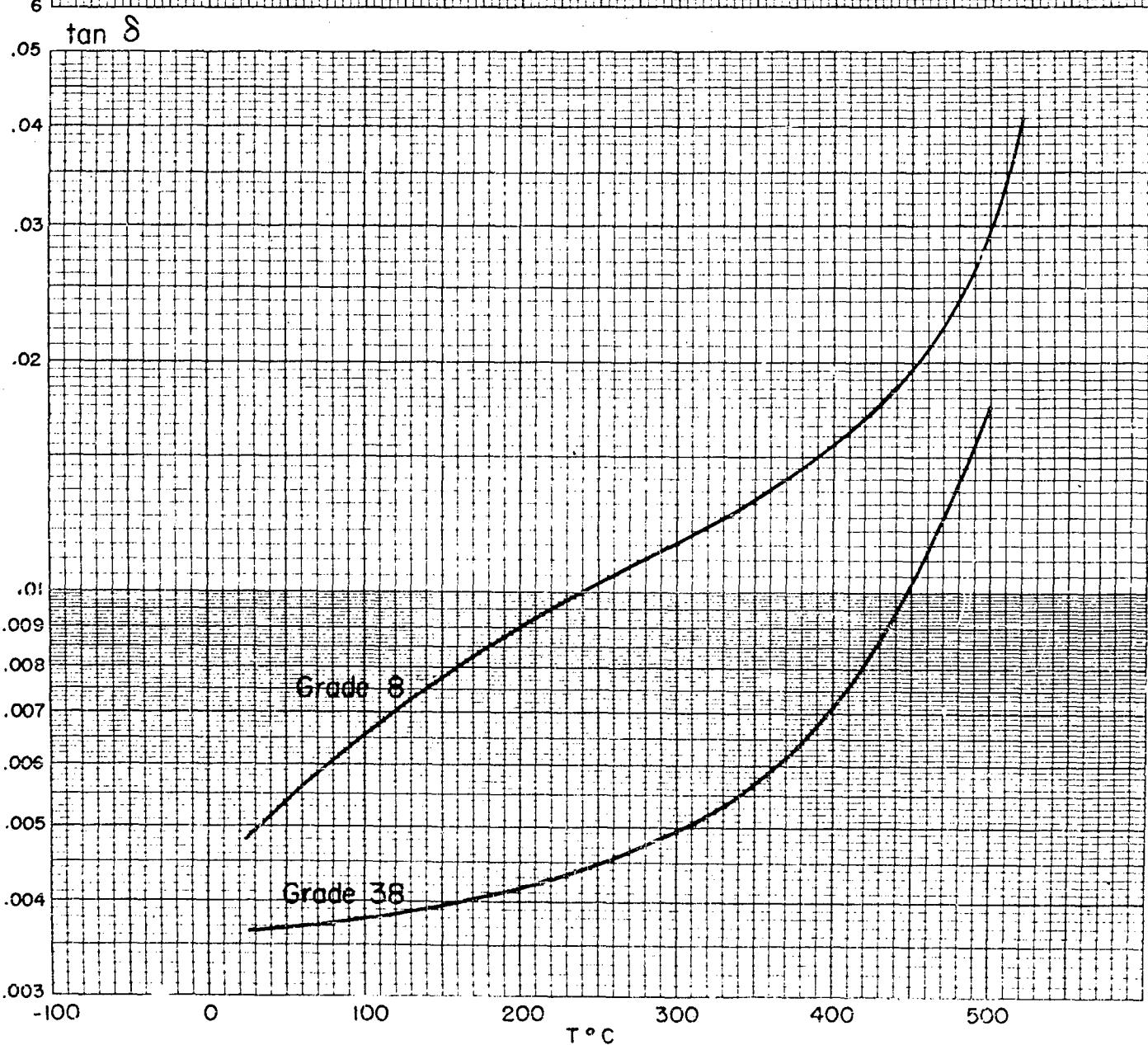
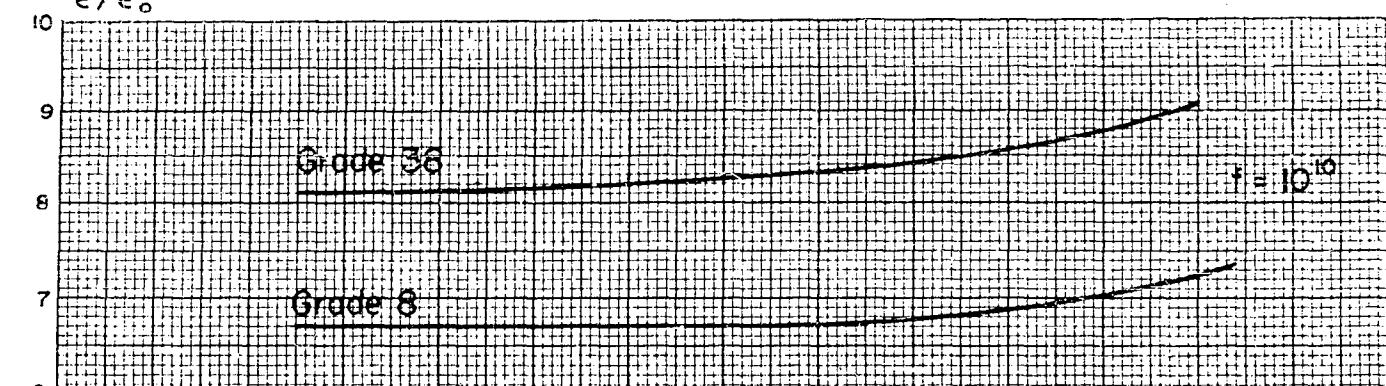
General Electric



Mica and Glass (cont.)

Mykroy Grade 8, Grade 38
 ϵ'/ϵ_0

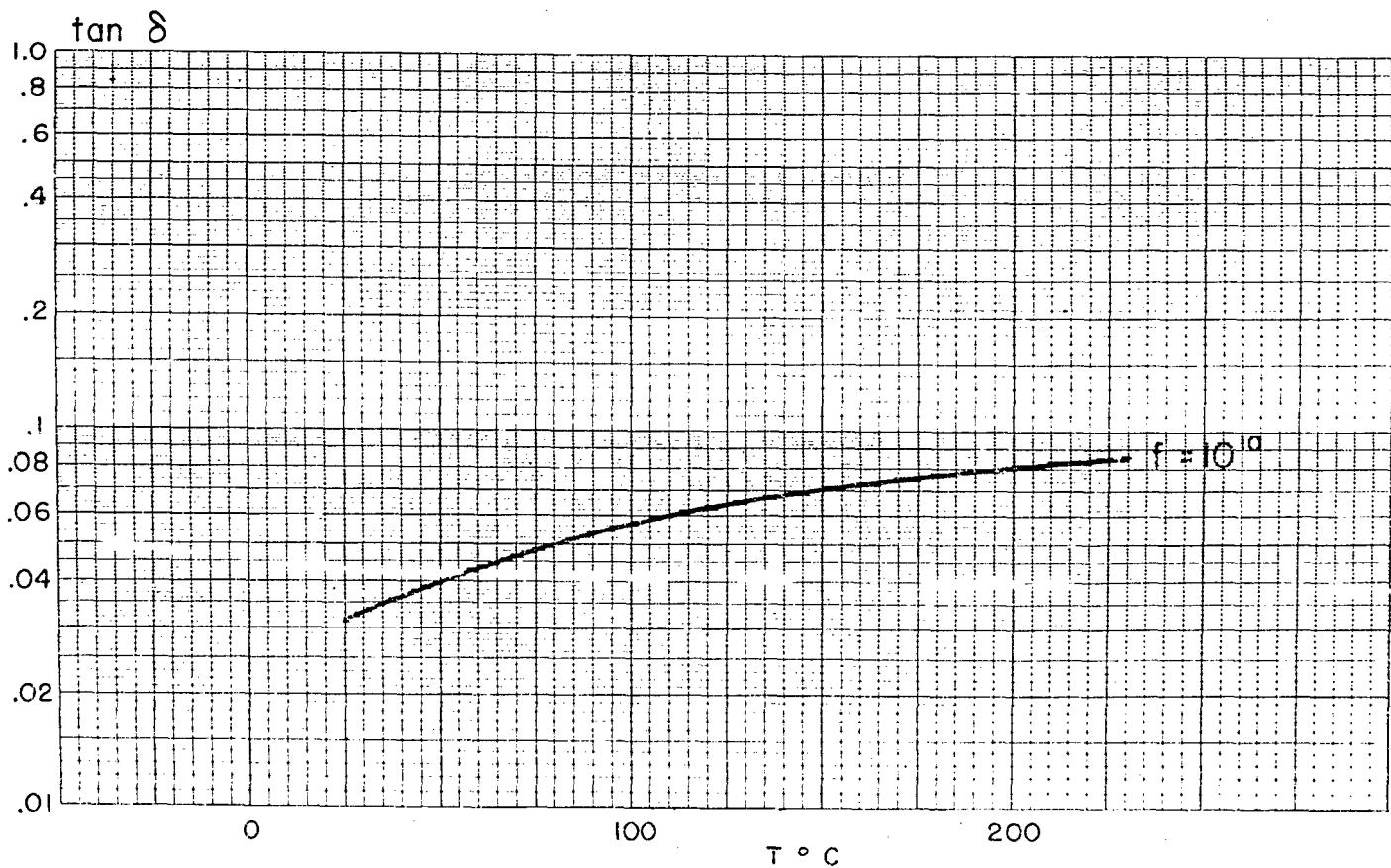
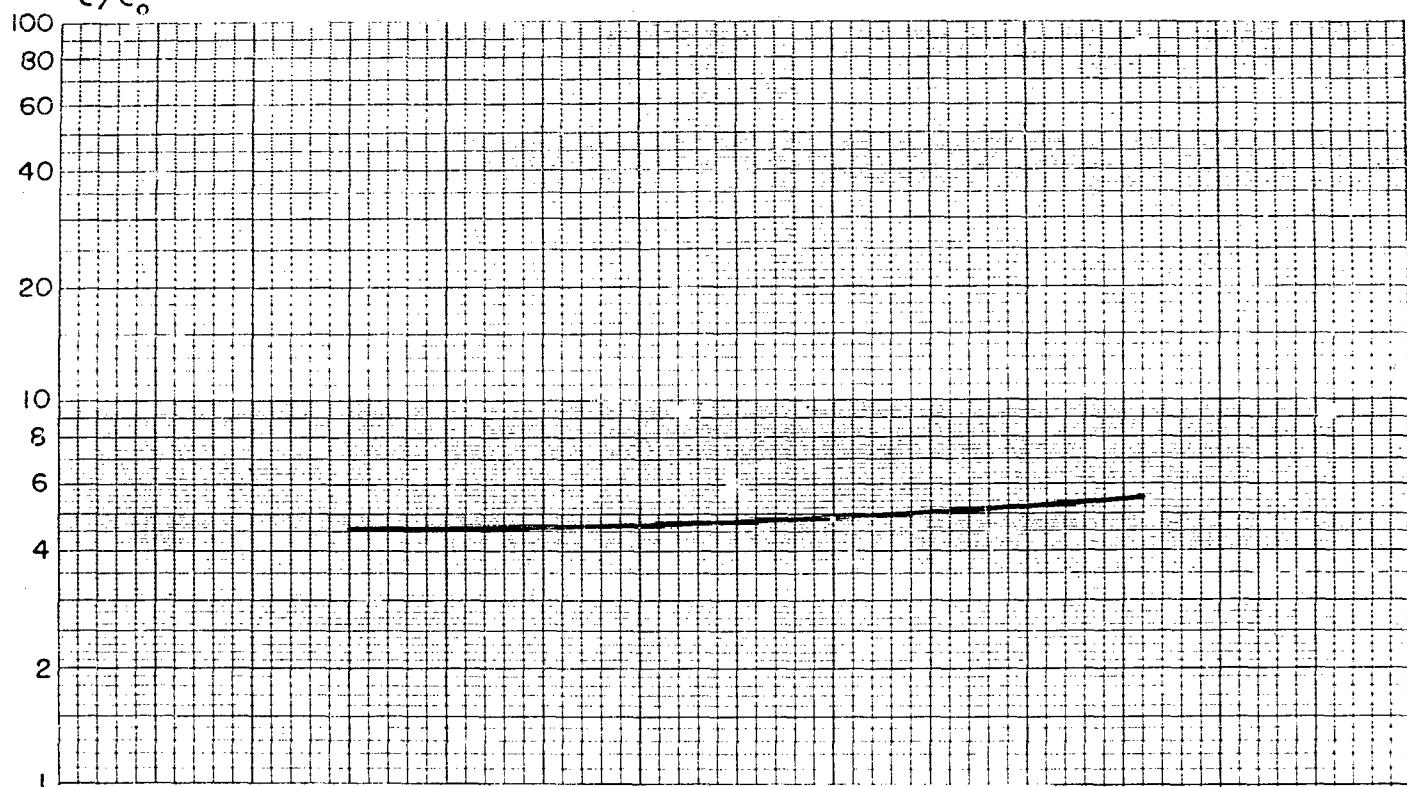
Electronic Mech.



Phenol-formaldehyde Resins

Resinox 10231
 ϵ'/ϵ_0

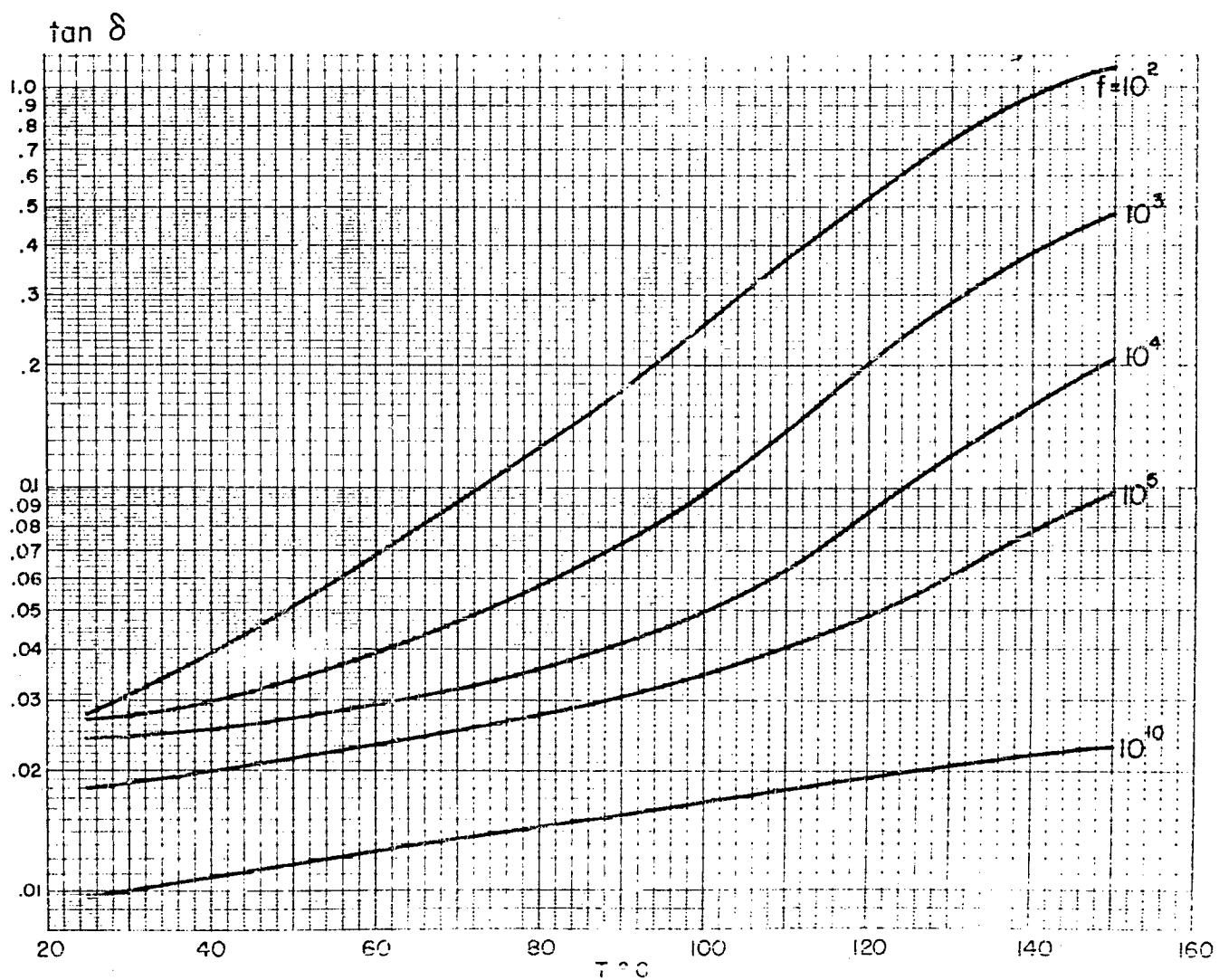
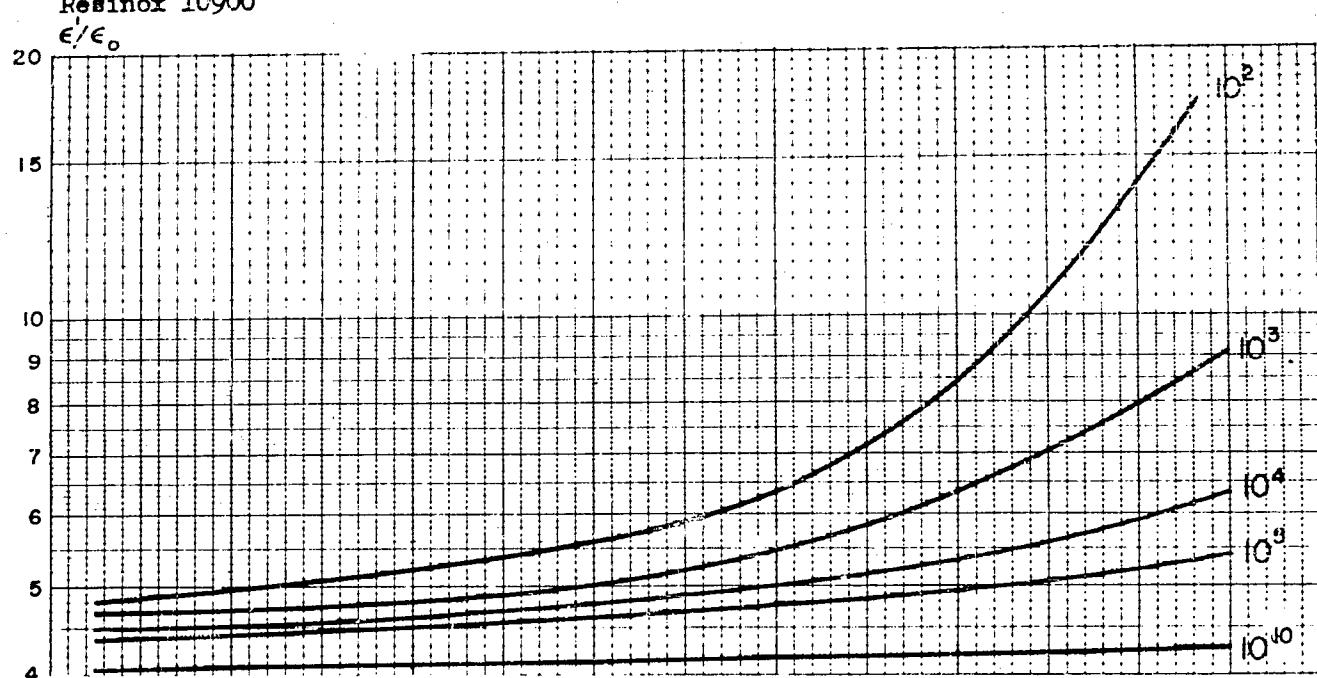
Monsanto



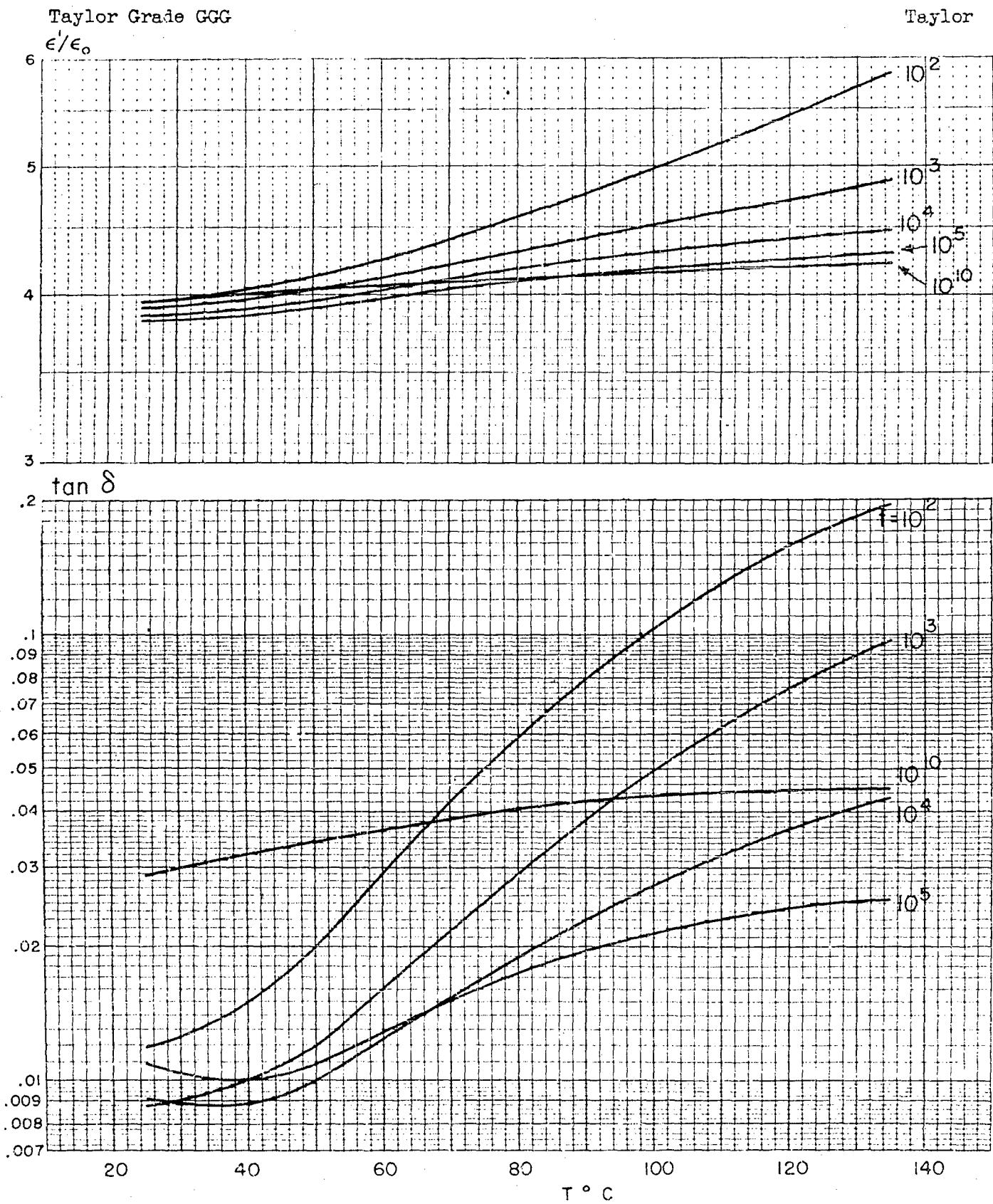
Phenol-formaldehyde Resins (cont.)

Resinox 10900

Monsanto



Phenol-formaldehyde Resins (cont.)

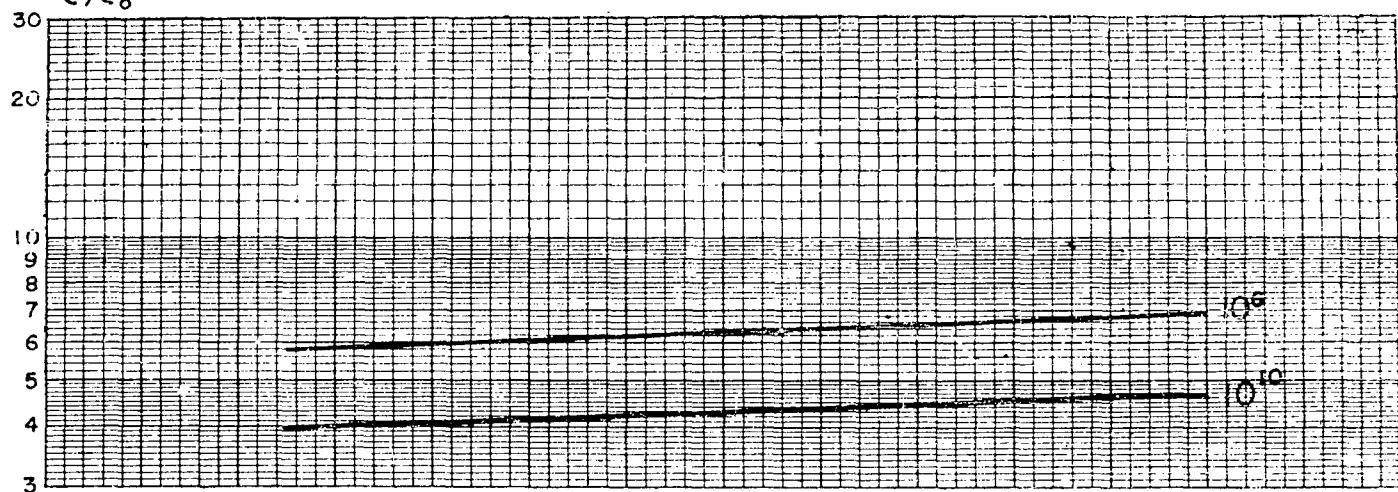


Melamine-formaldehyde Resin

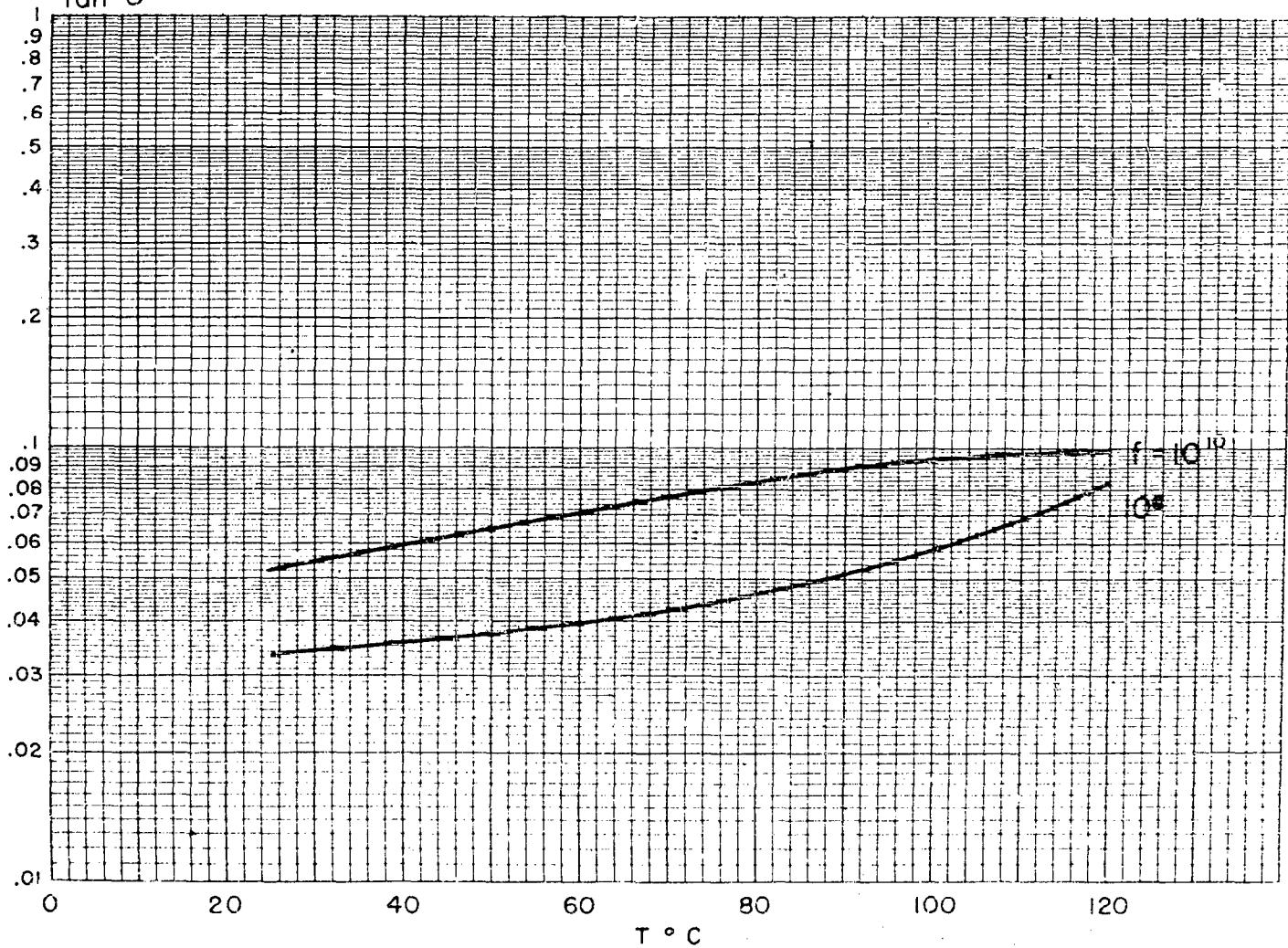
Melmac Molding Compound 1502

ϵ'/ϵ_0

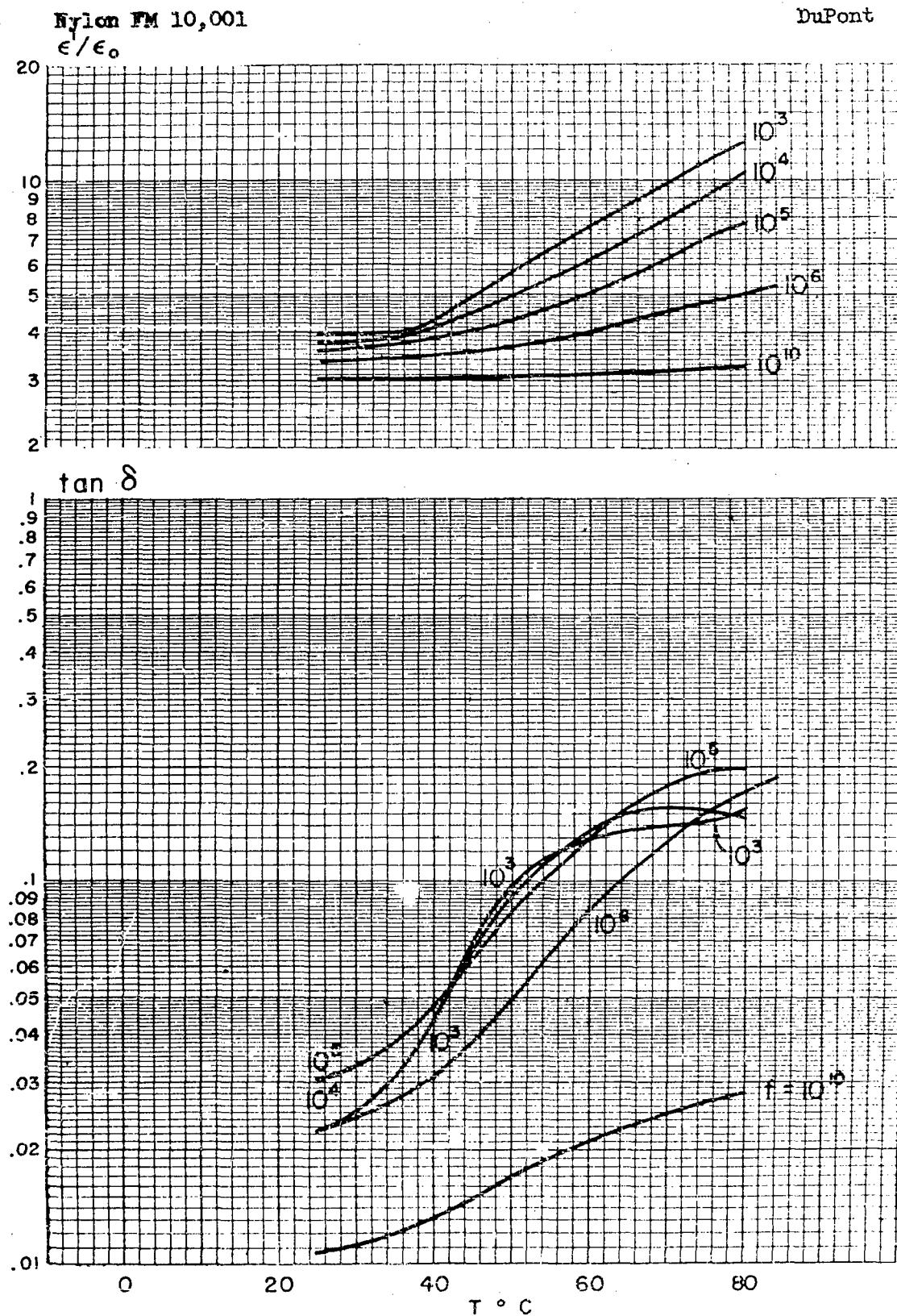
Amer. Cyanamid



$\tan \delta$



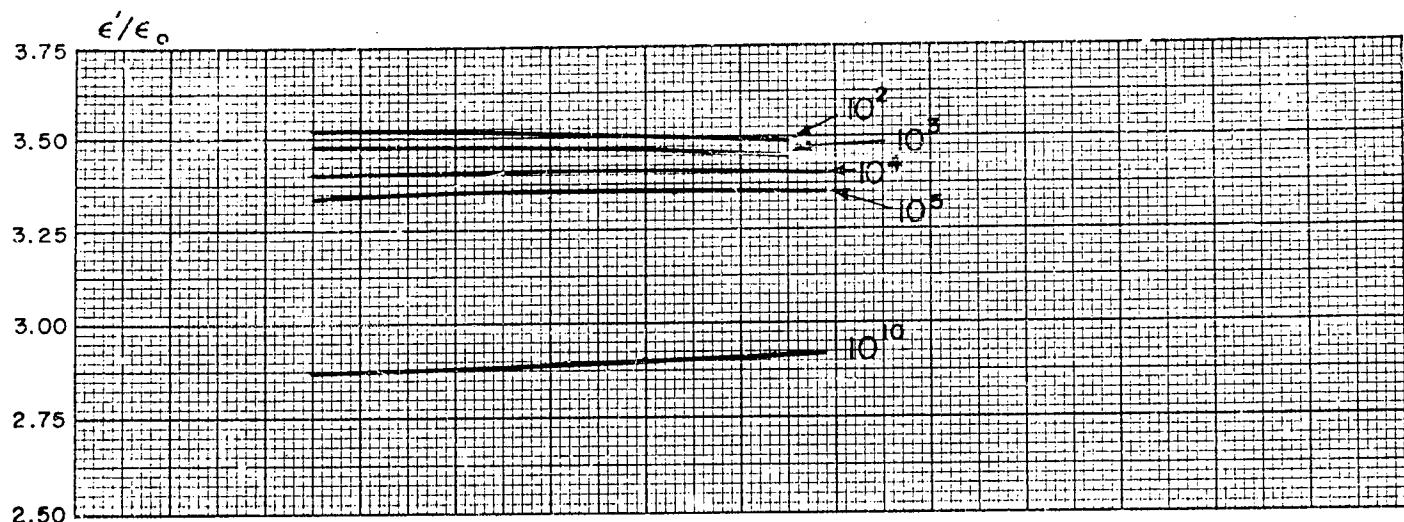
Polyamide Resin



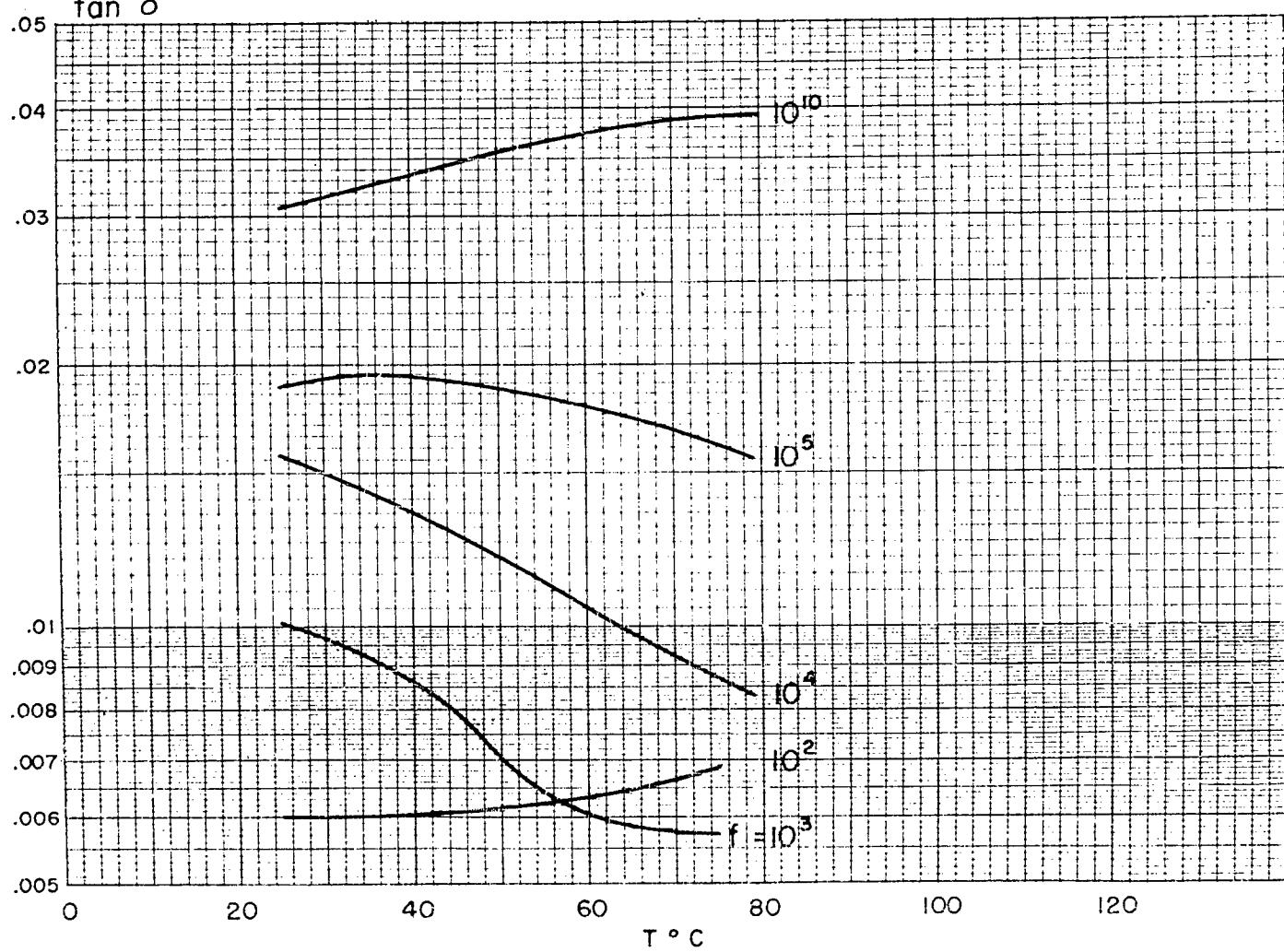
Cellulose Propionate

Forticel

Celanese



$\tan \delta$

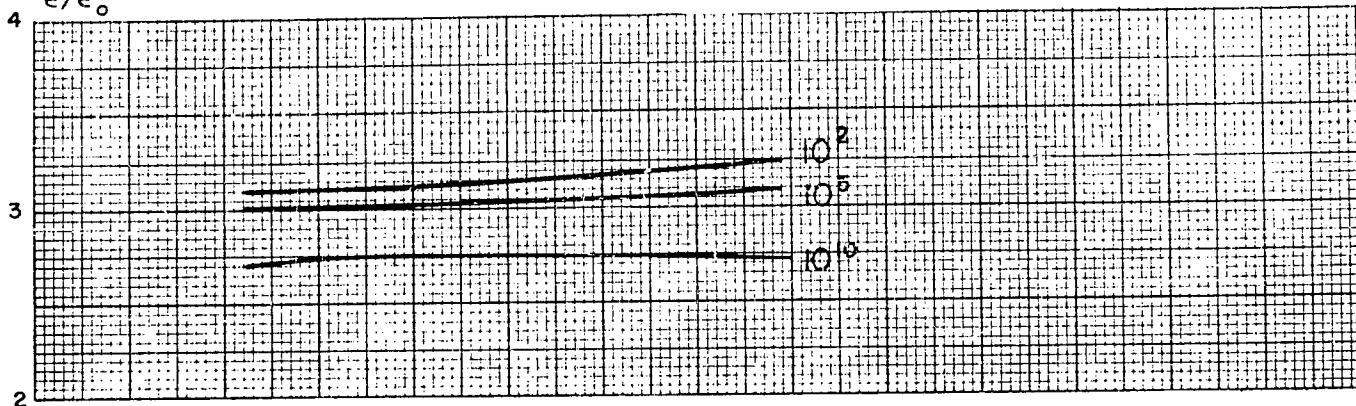


Ethyl Cellulose

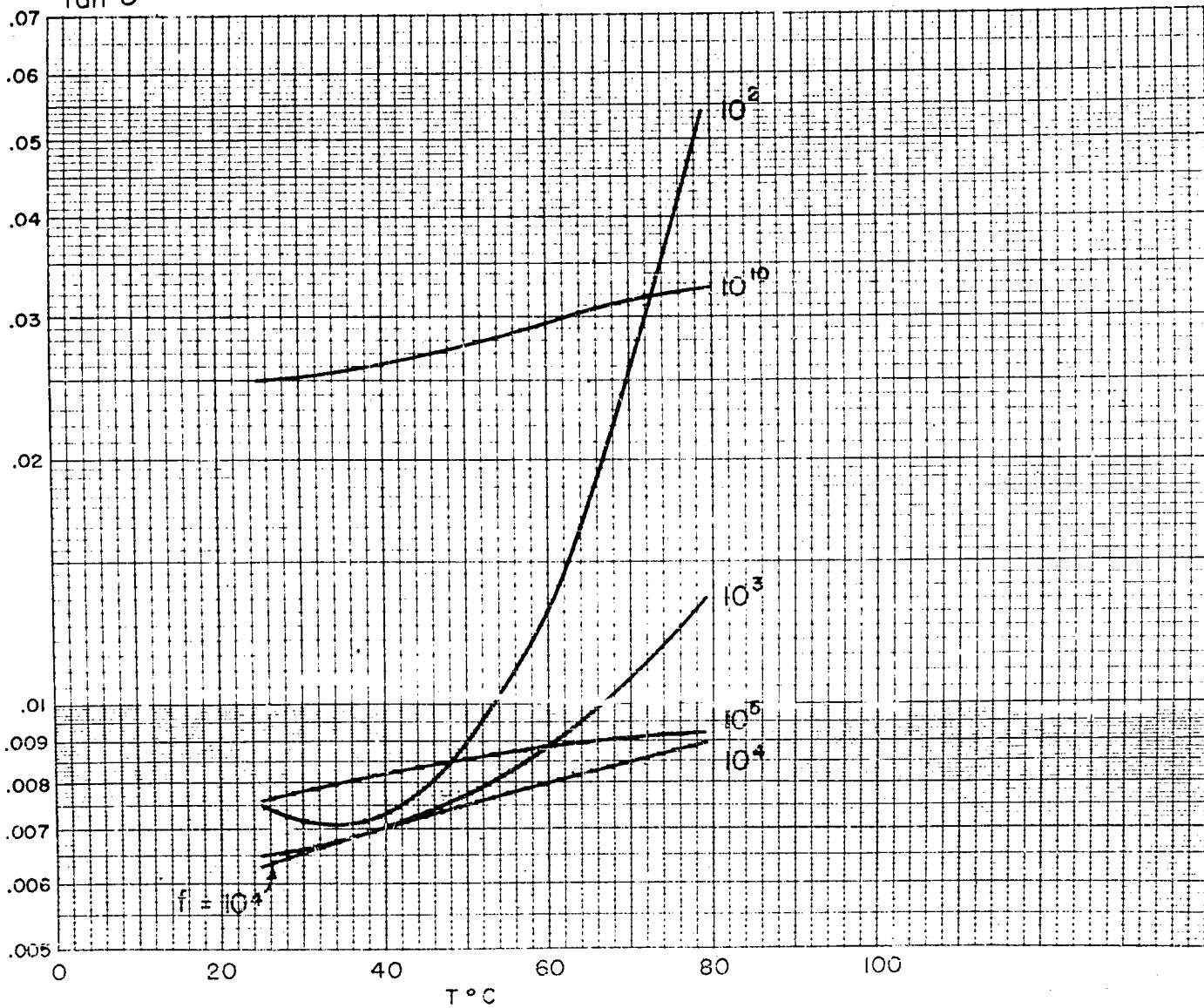
Ethocel LT5

Celanese

ϵ'/ϵ_0



$\tan \delta$

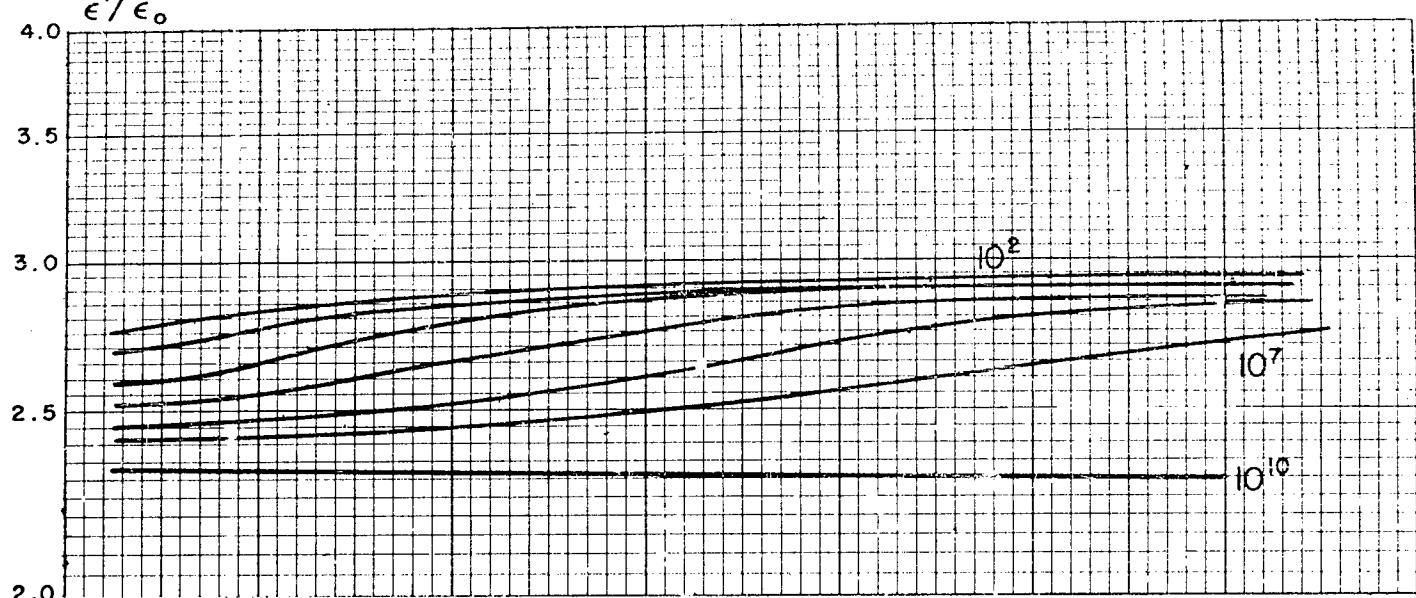


Polychlorotrifluoroethylene

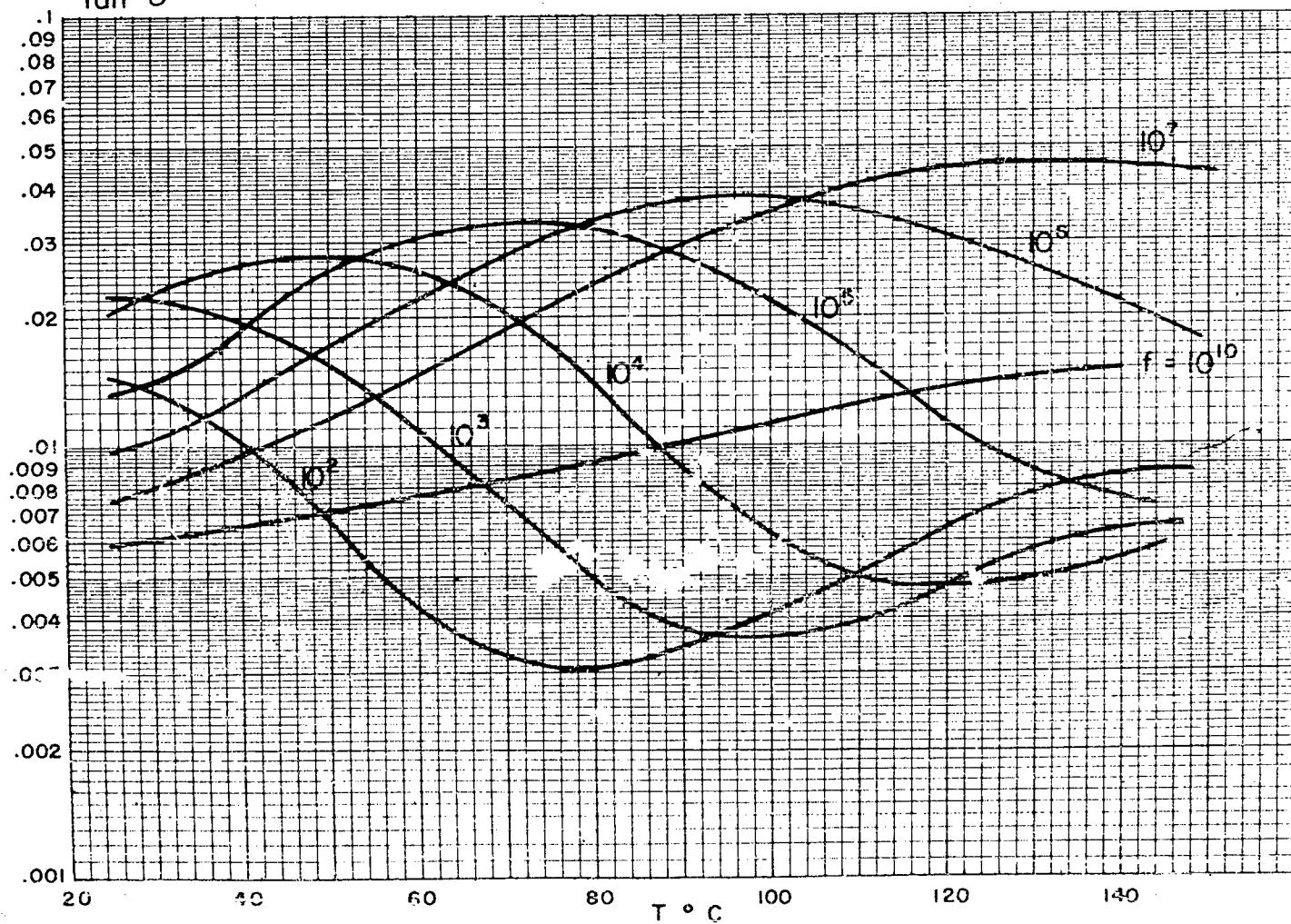
Kel-F Grade 300

ϵ'/ϵ_0

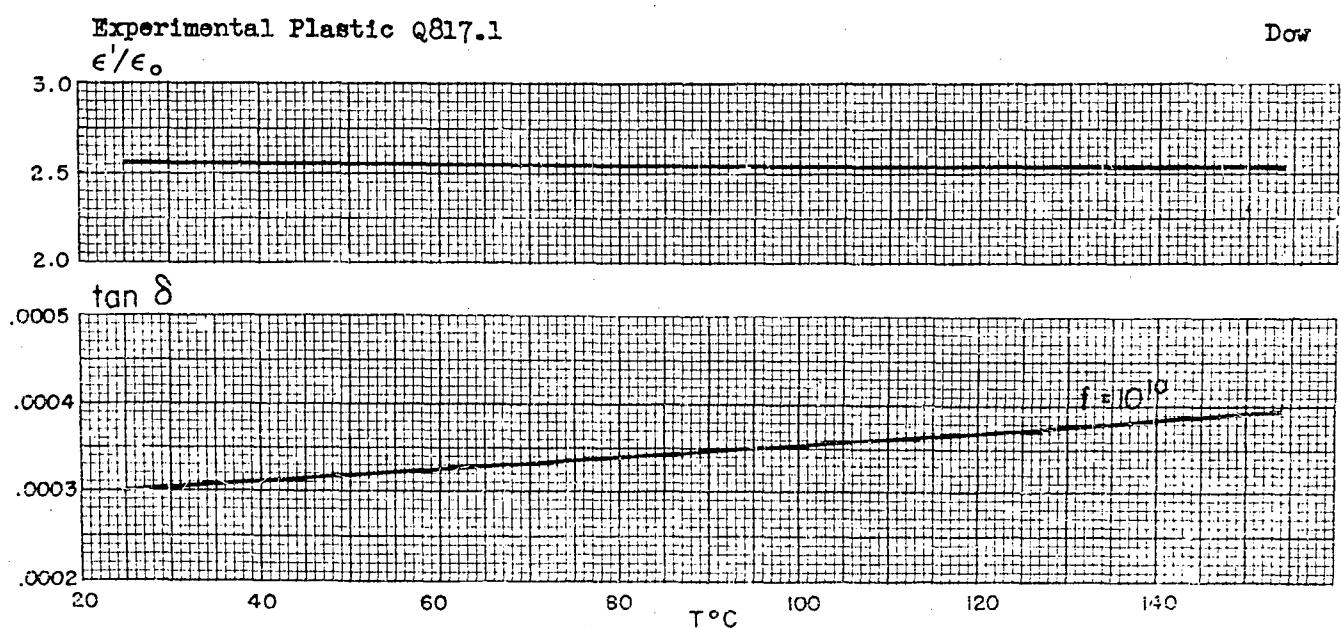
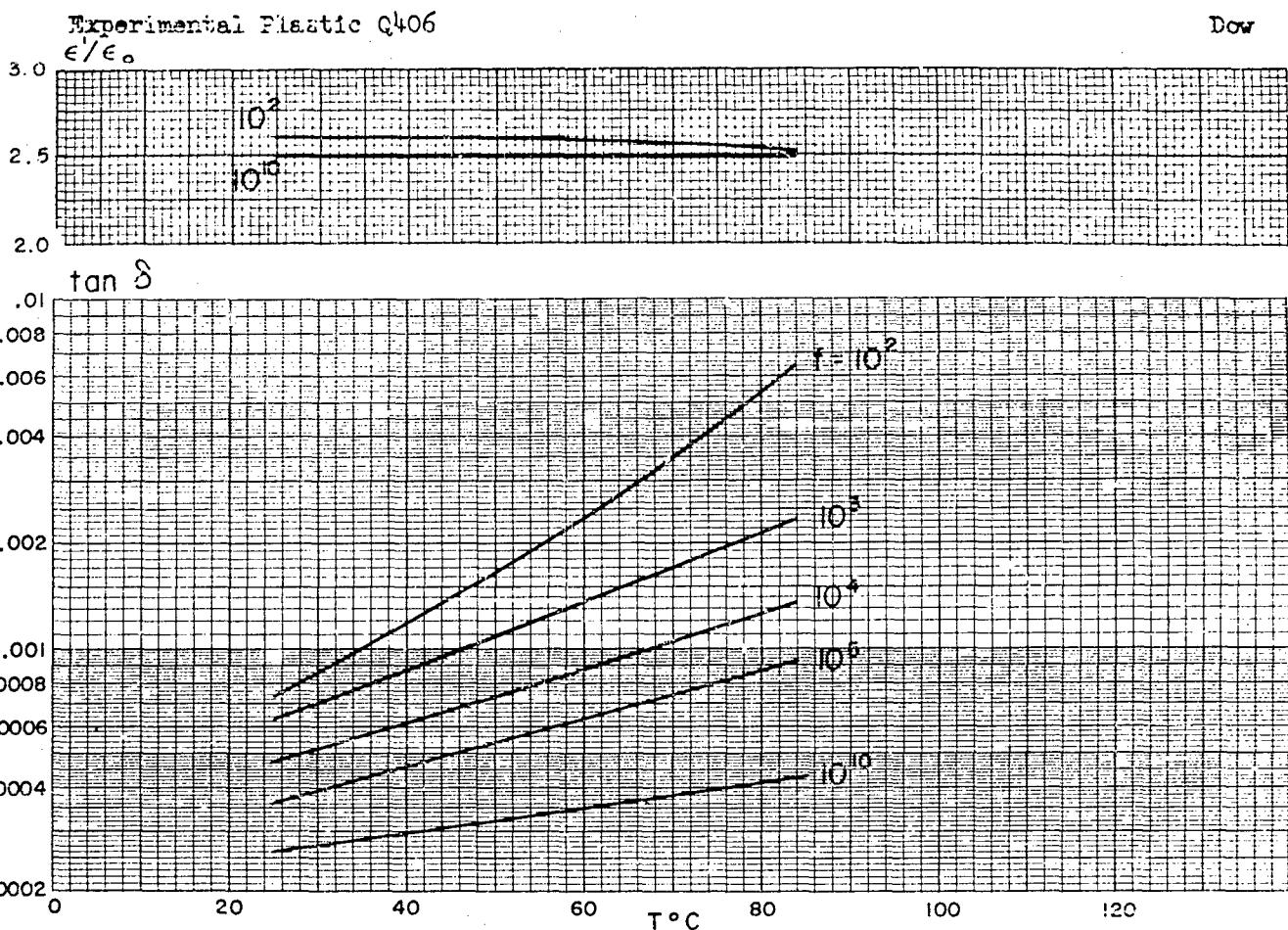
Kellogg



$\tan \delta$



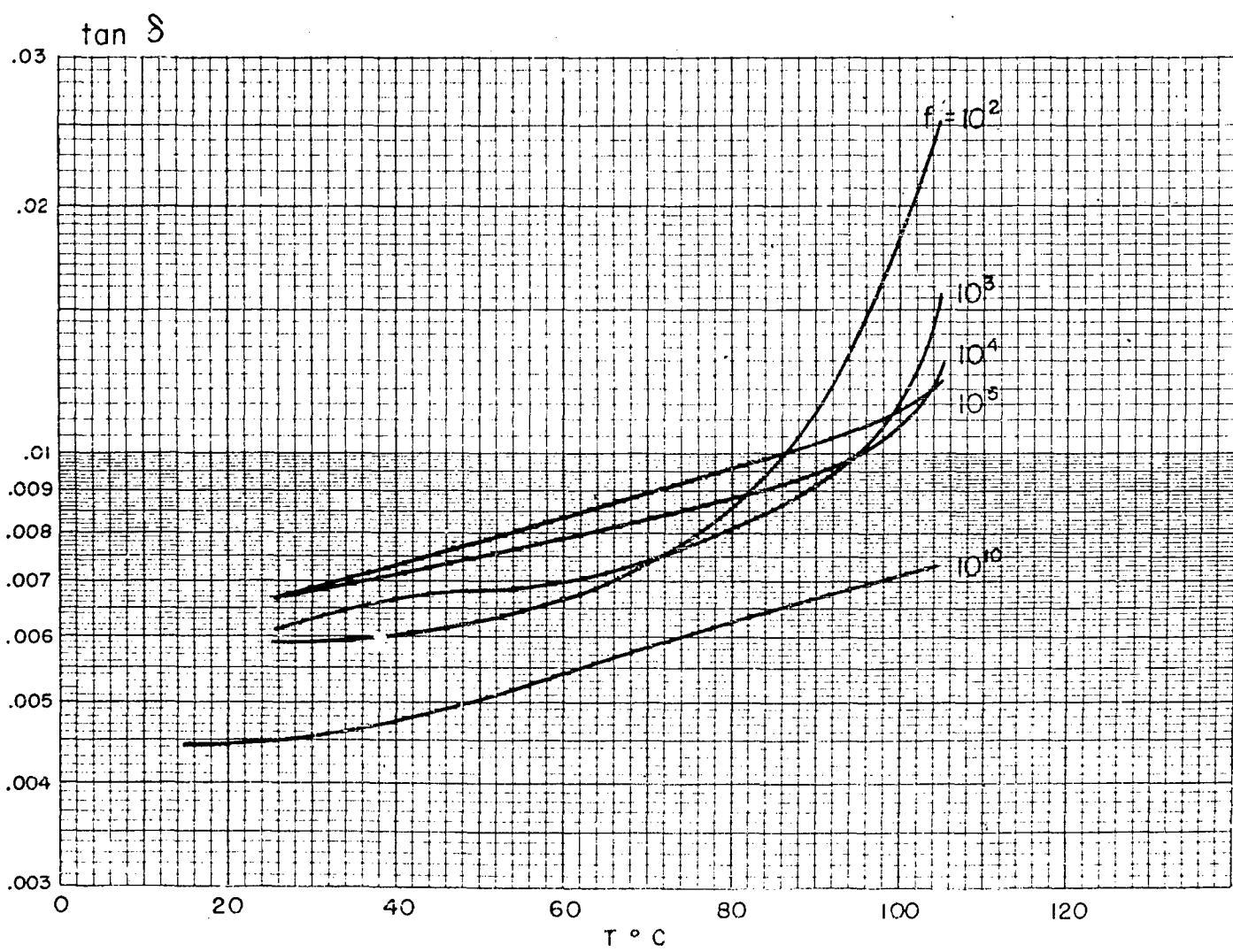
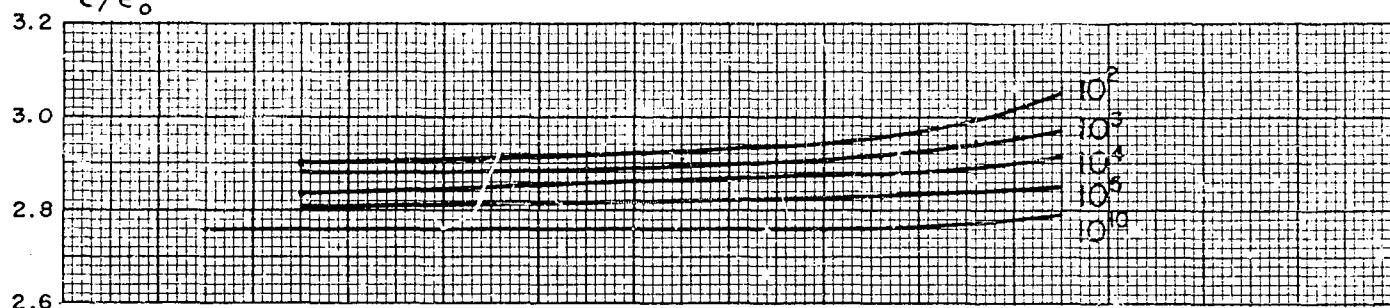
Miscellaneous Vinyls



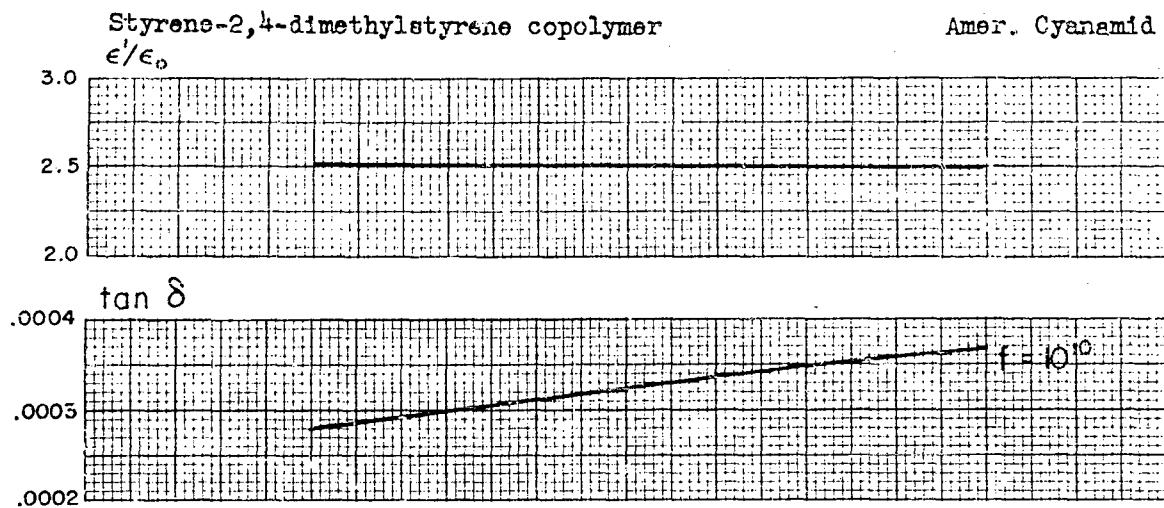
Styrene Copolymers, Linear

Styrene-acrylonitrile copolymer
 ϵ'/ϵ_0

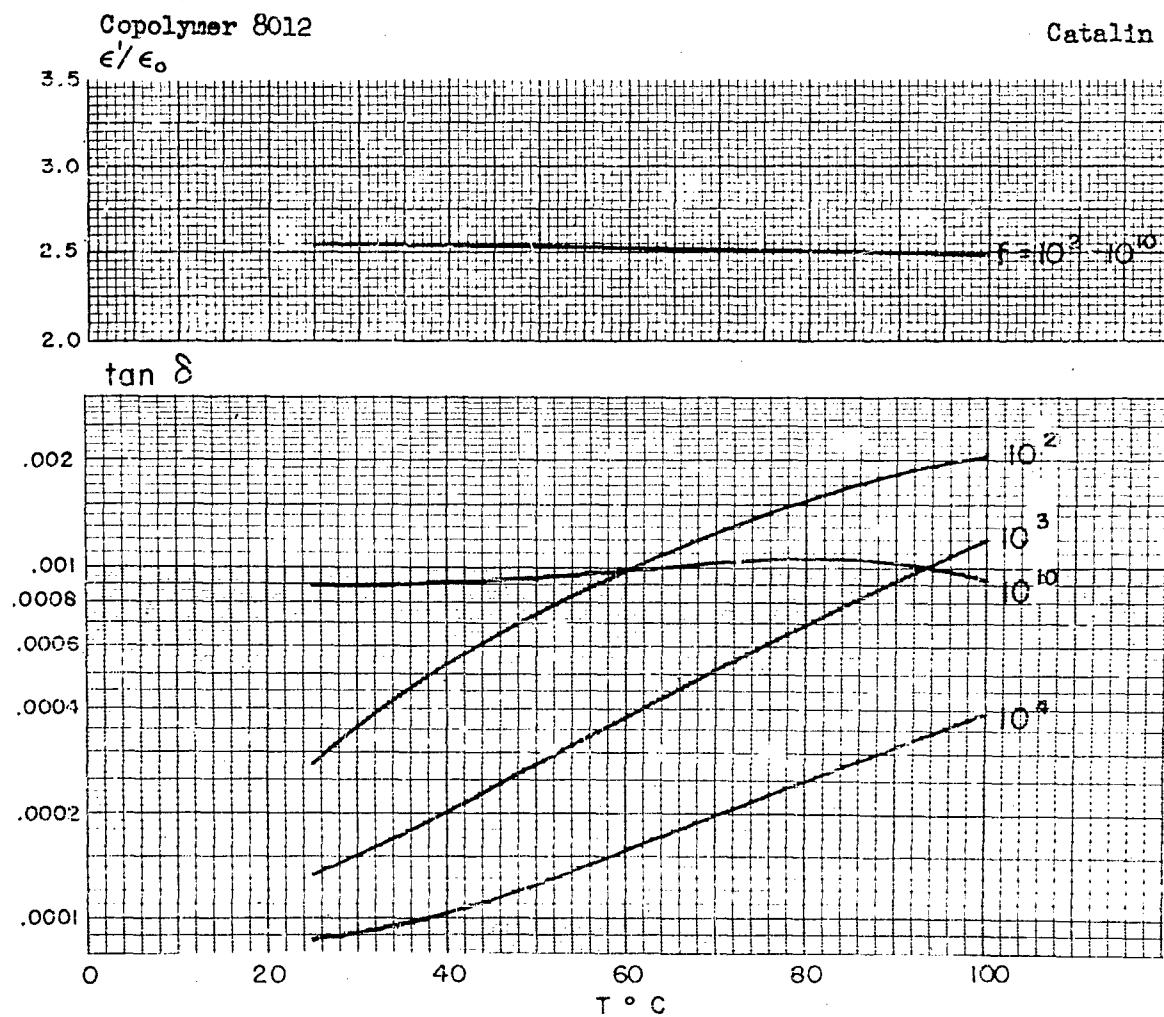
Amer. Cyanamid



Styrene Copolymers, Linear (cont.)



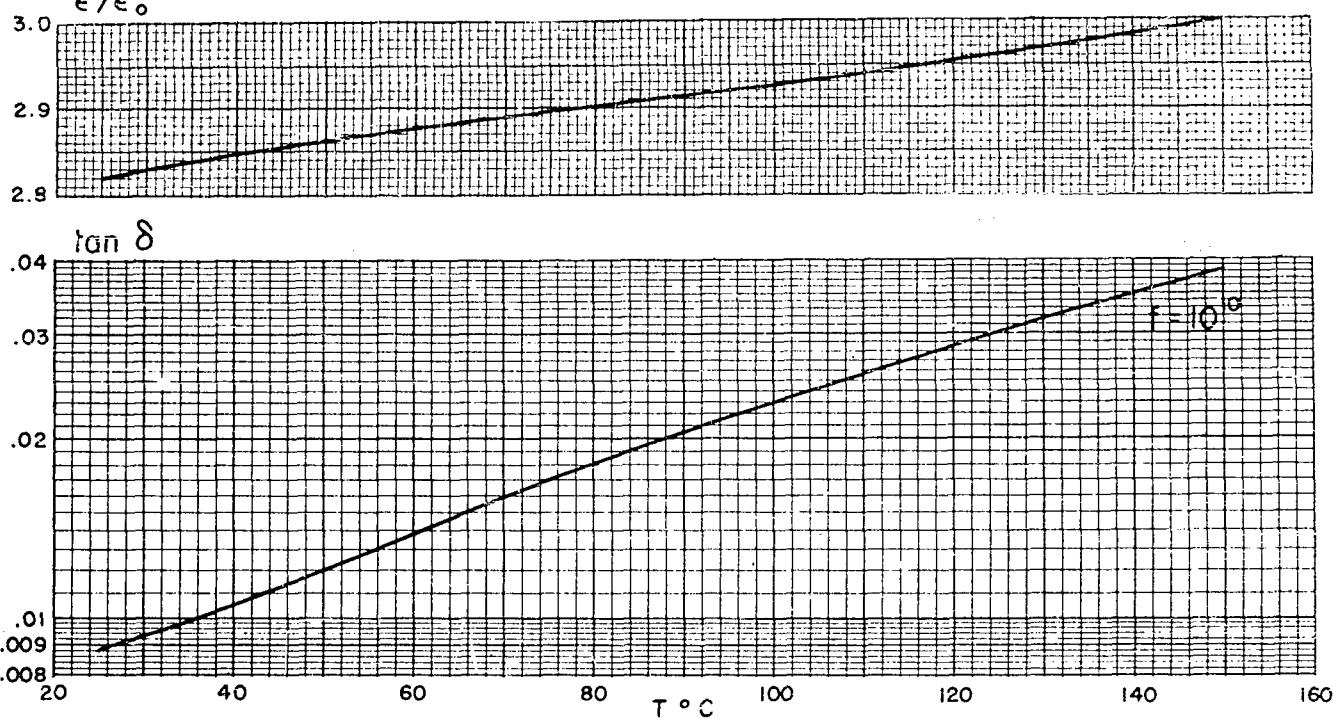
Styrene Copolymers, Cross-linked



Polyesters

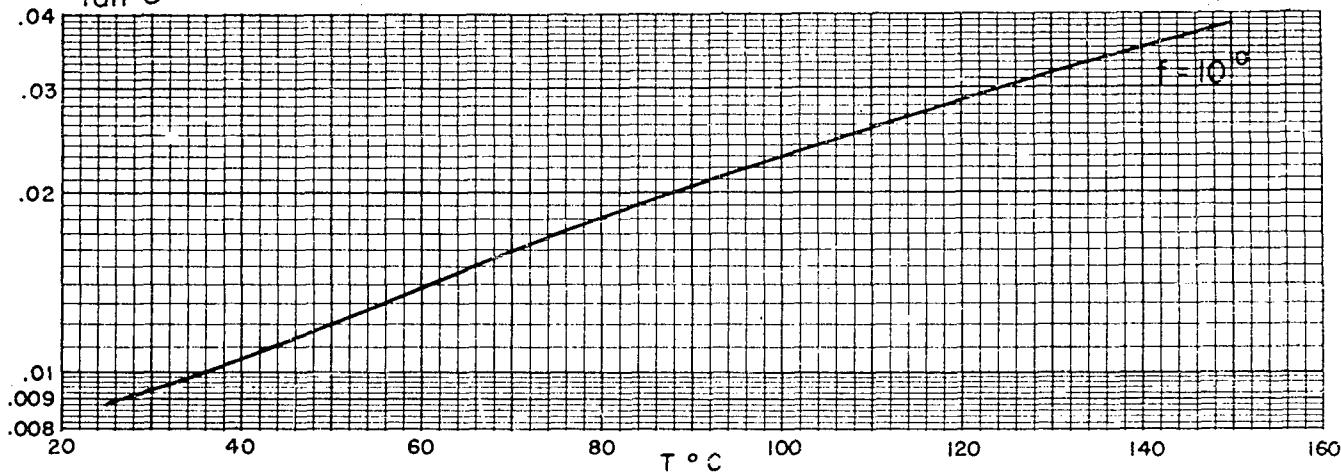
Laminac 4115

ϵ'/ϵ_0



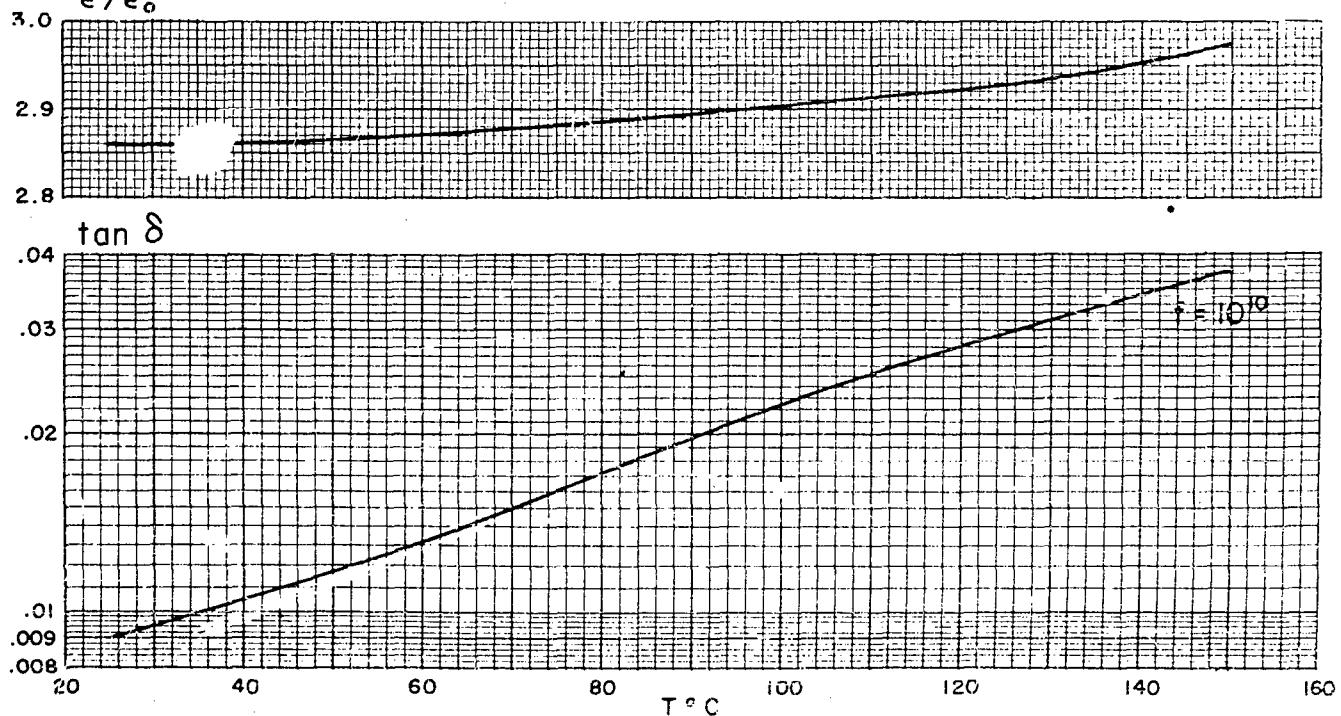
Amer. Cyanamid

$\tan \delta$



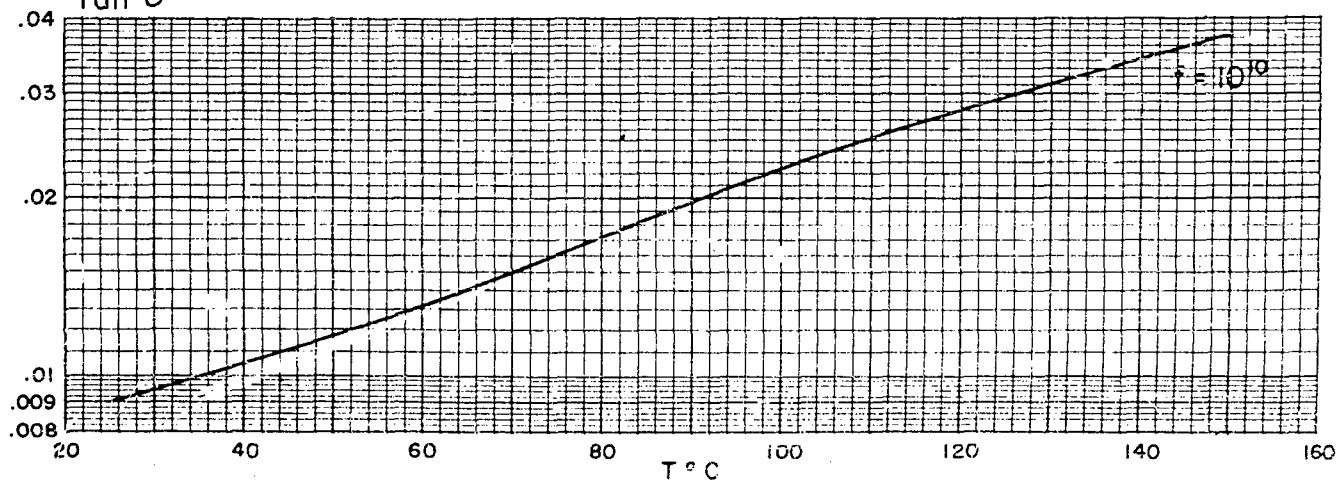
Laminac PDL7-627

ϵ'/ϵ_0

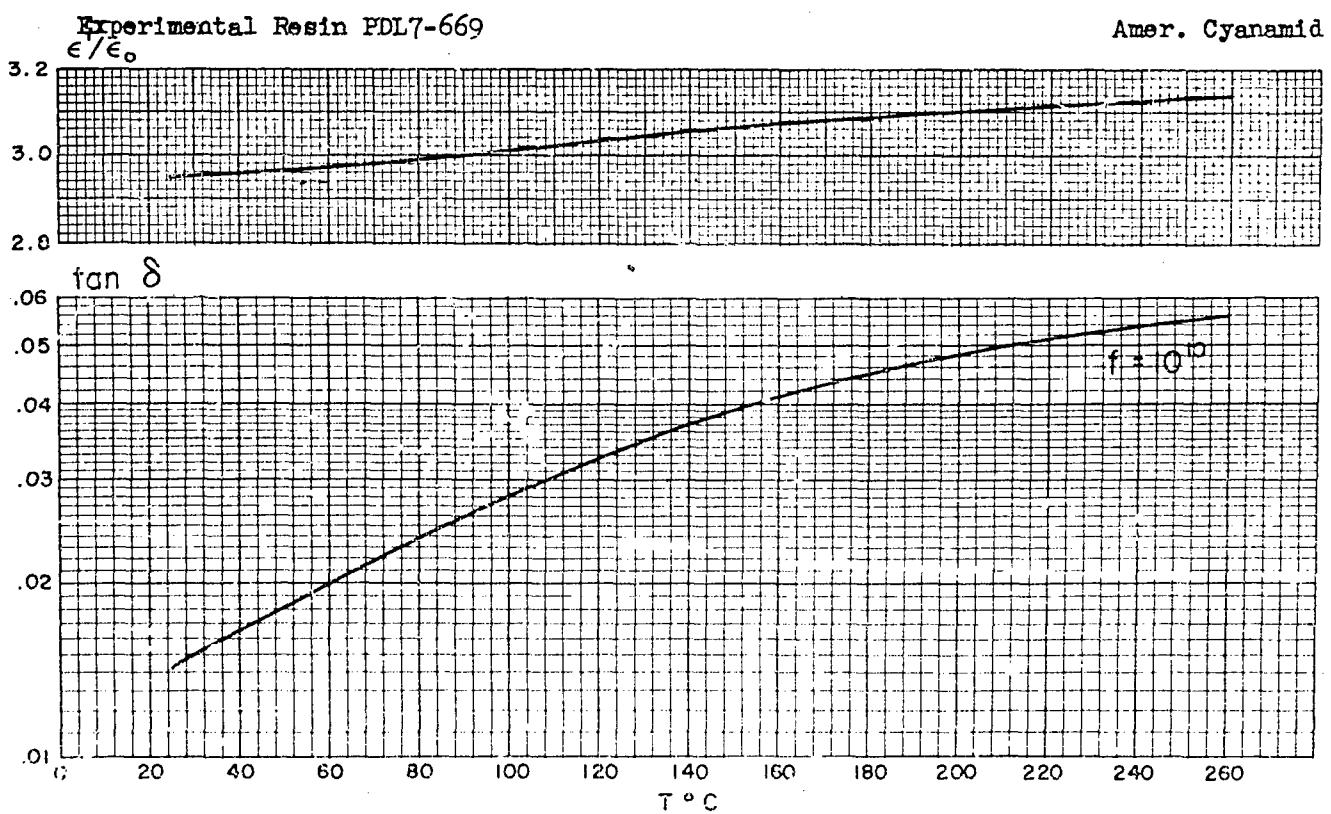
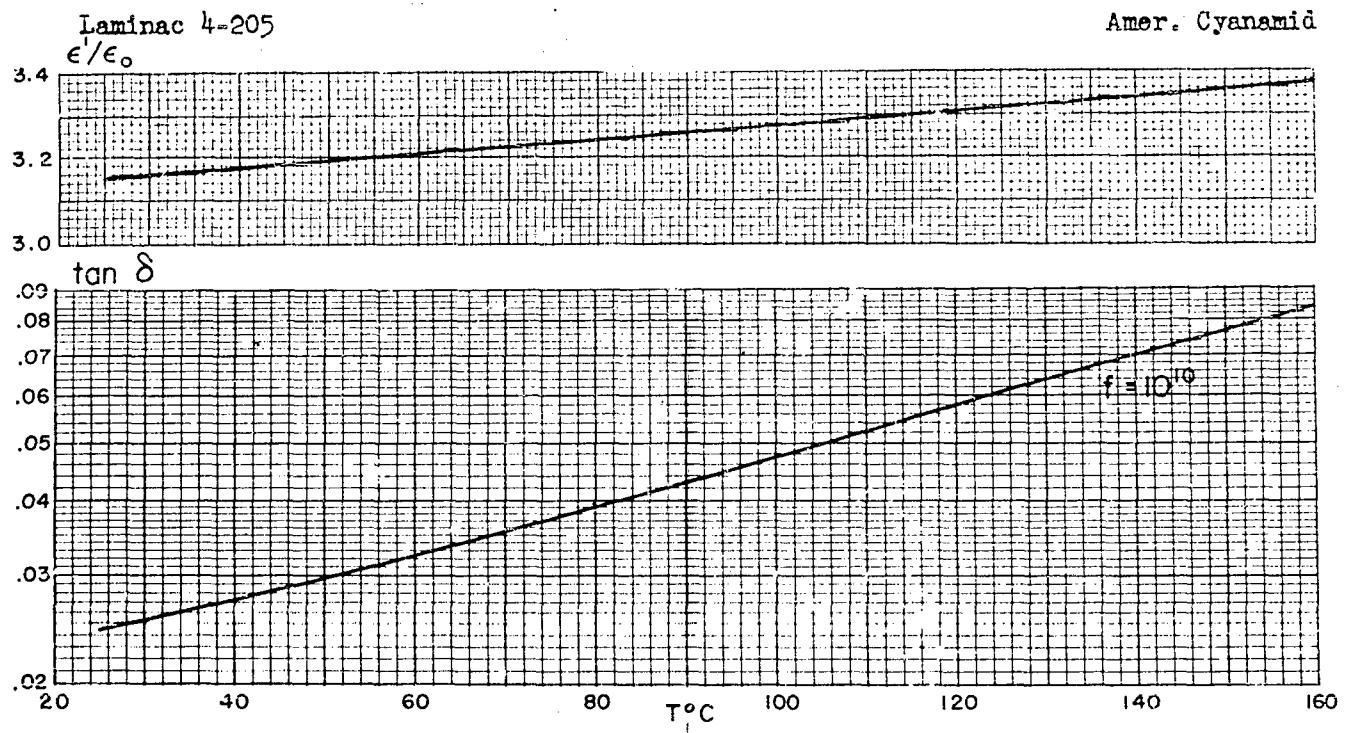


Amer. Cyanamid

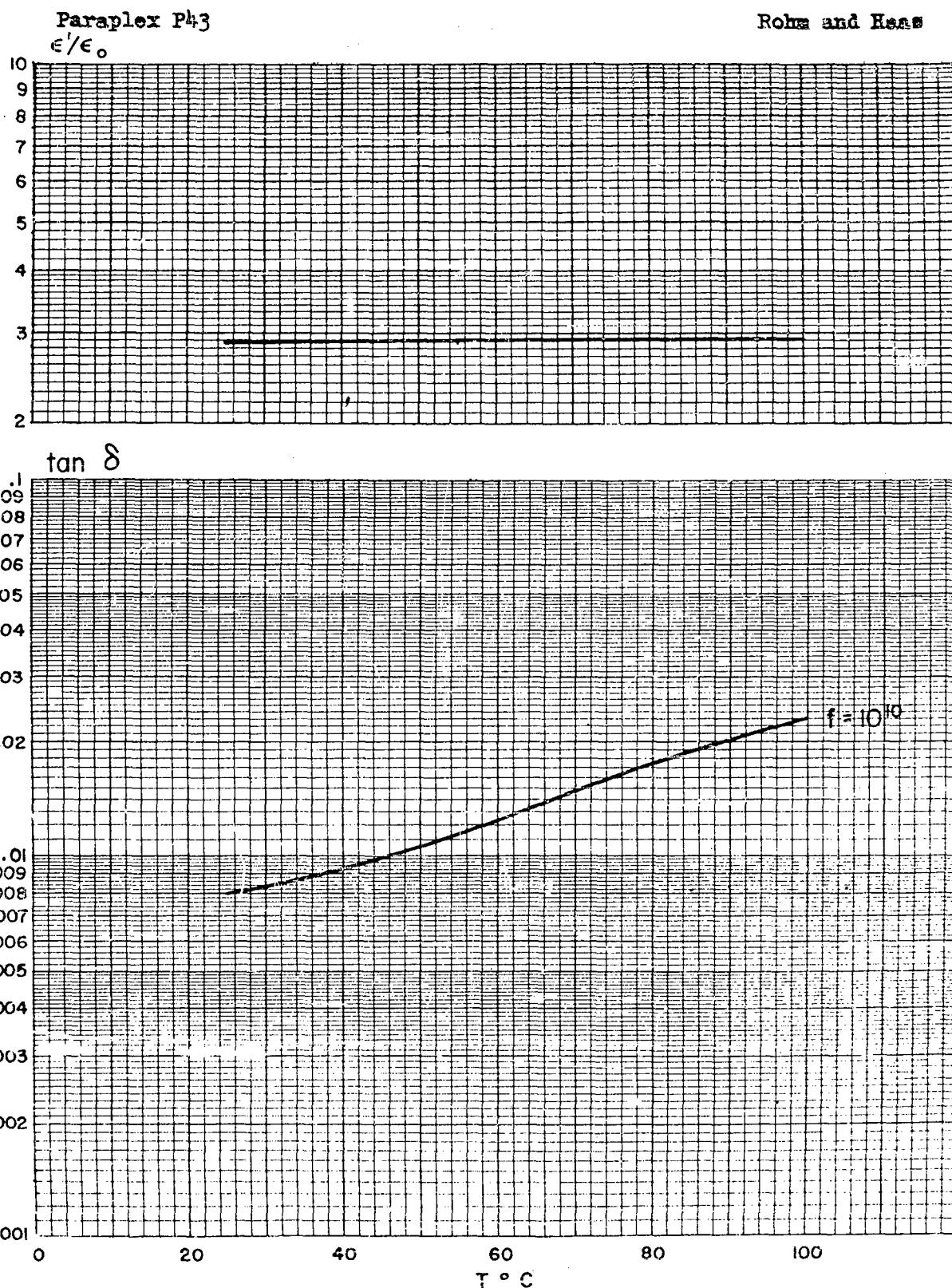
$\tan \delta$



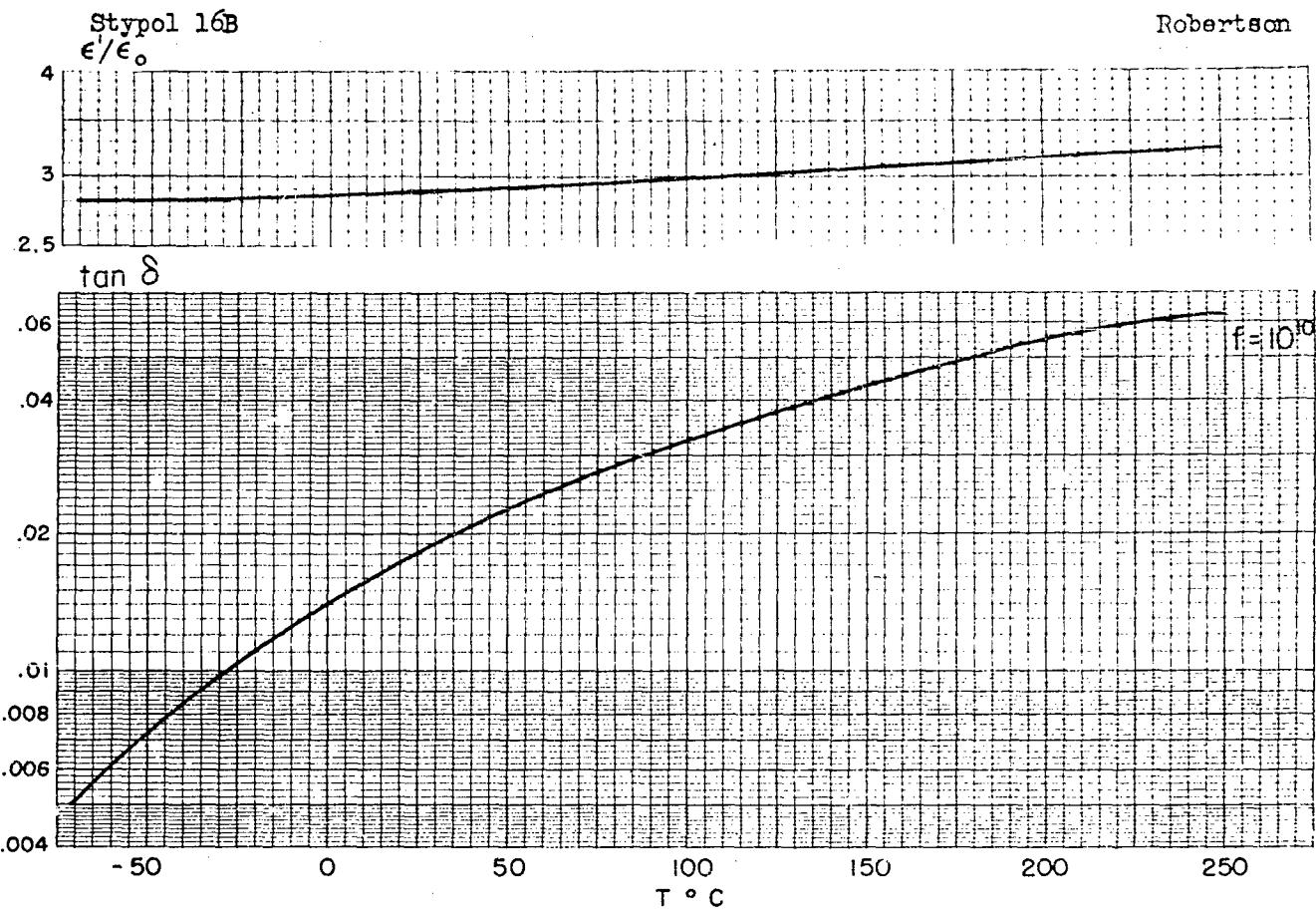
Polyesters (cont.)



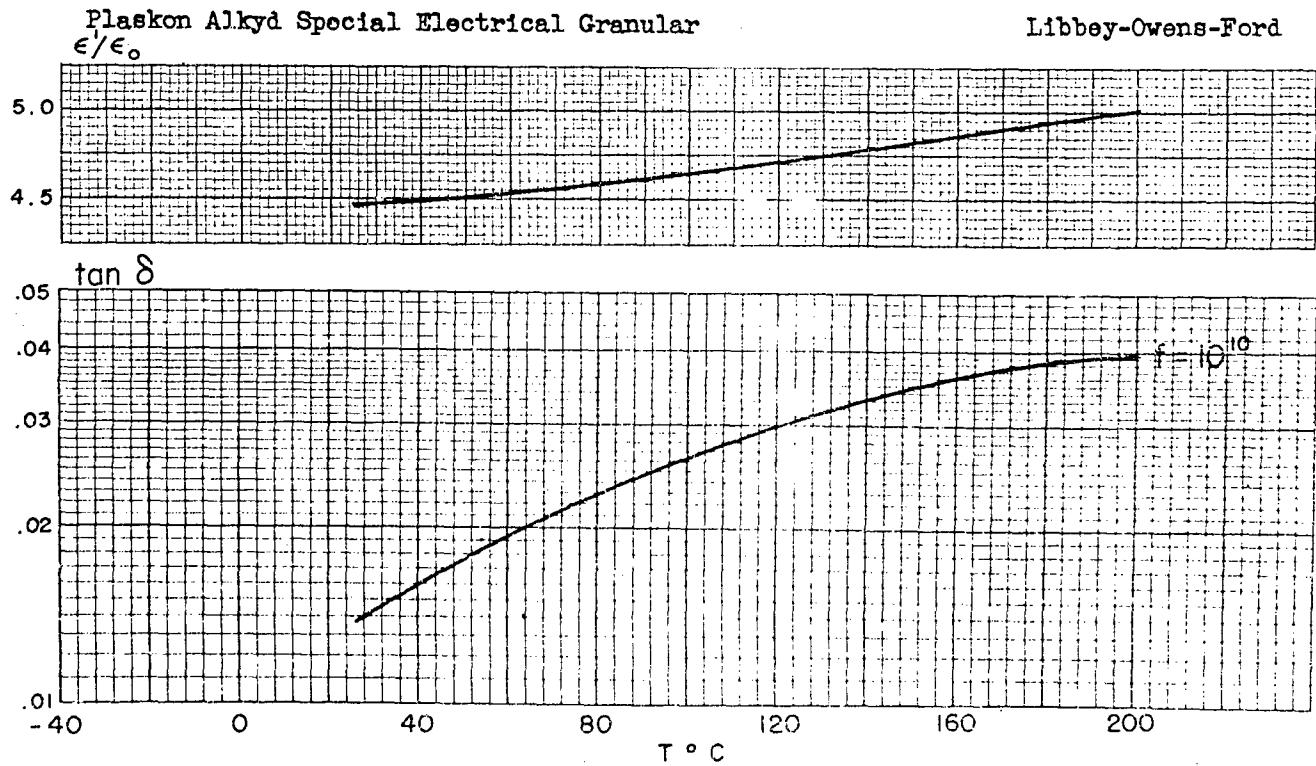
Polyesters (cont.)



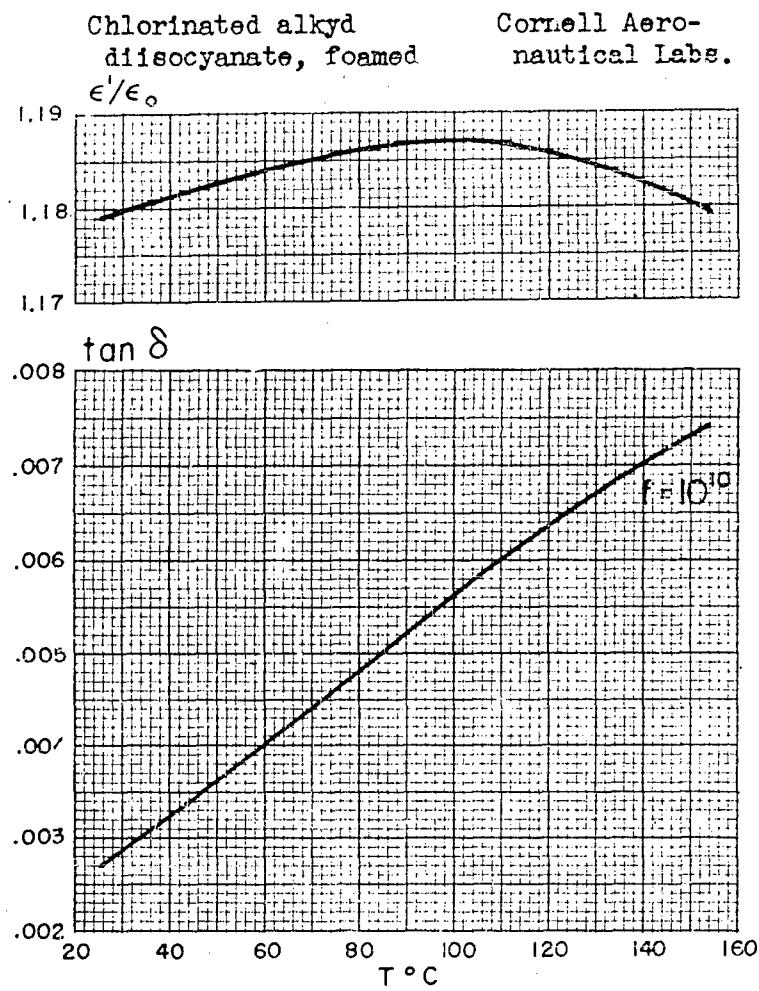
Polyesters (cont.)



Alkyd Resins



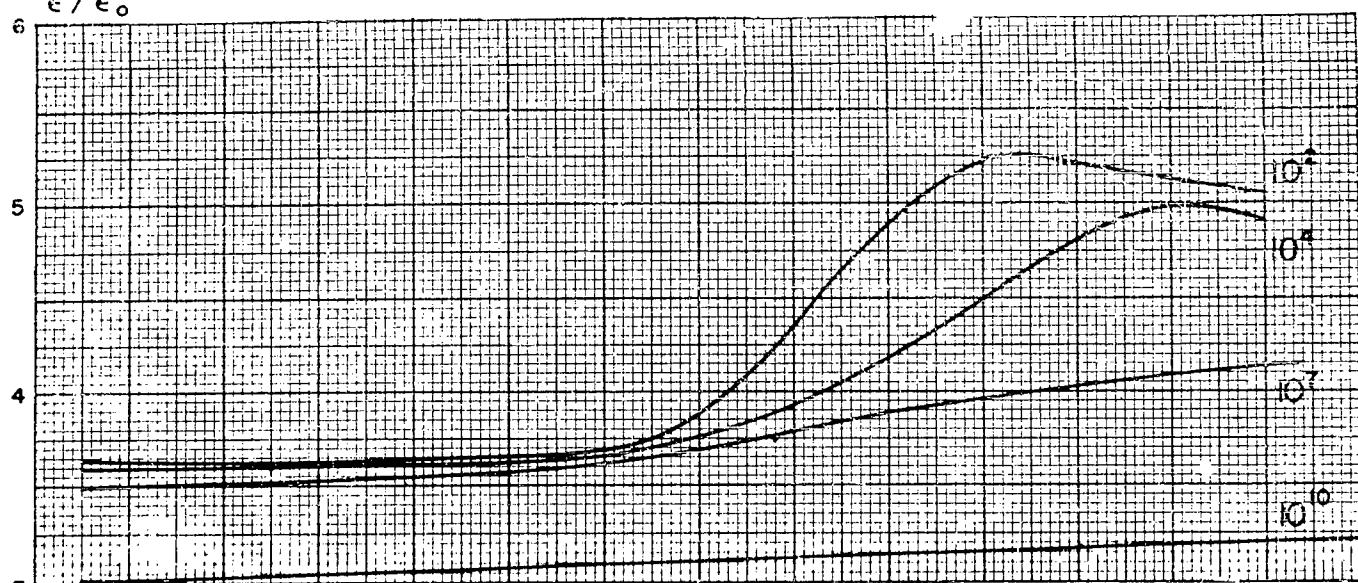
Alkyd Resins (cont.)



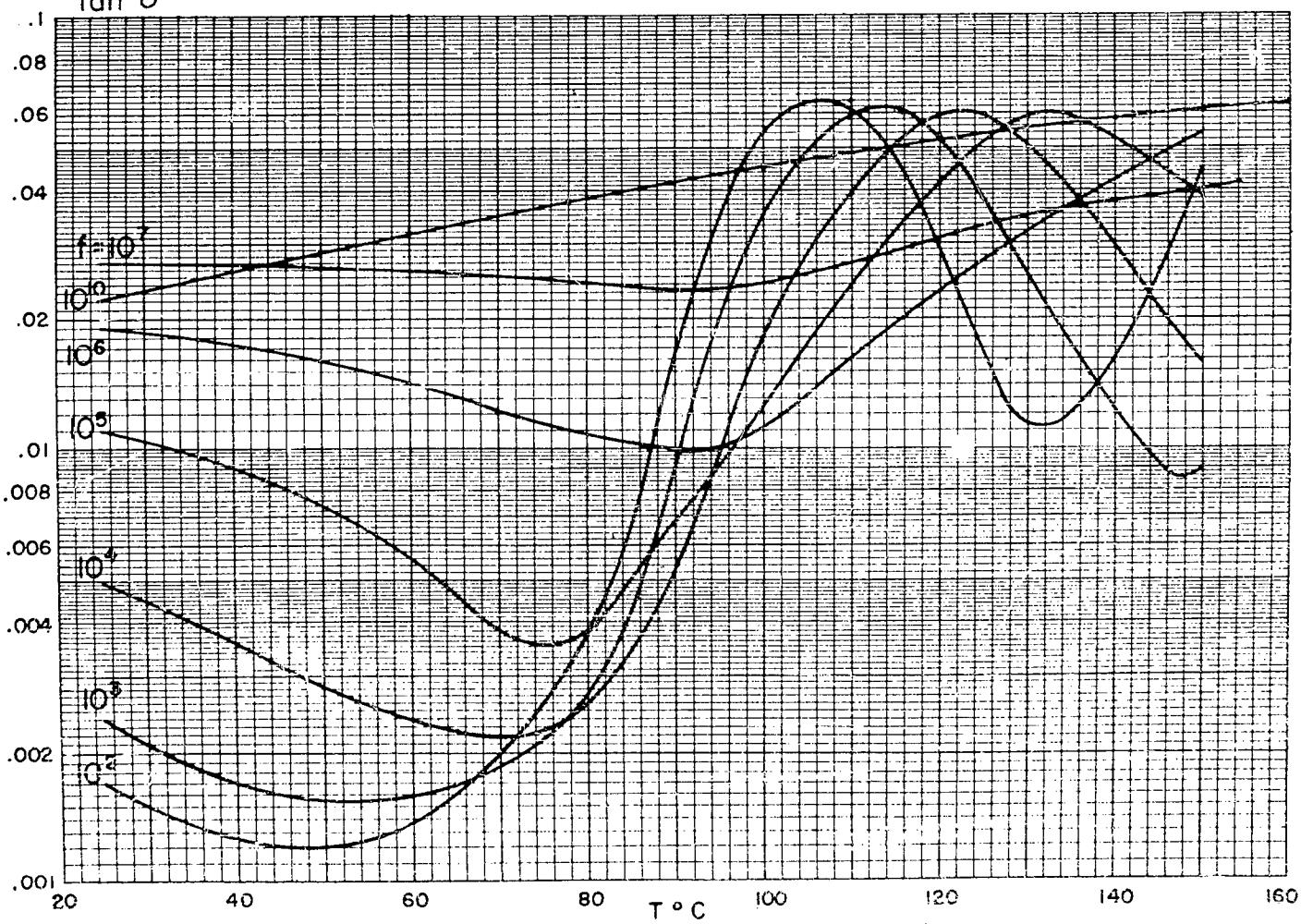
Epoxy Resin

Araldite Casting Resin Type B
 ϵ / ϵ_0

Ciba



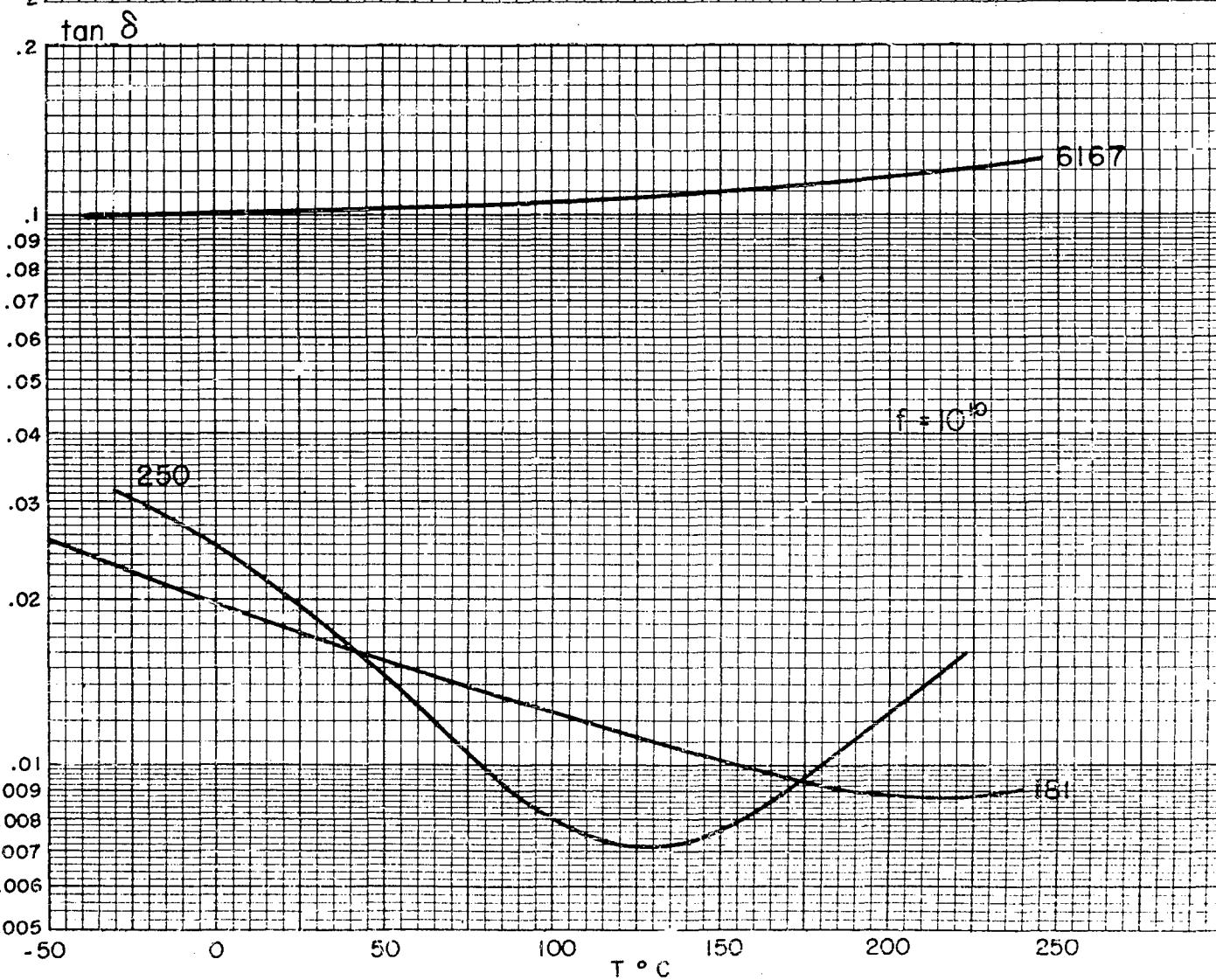
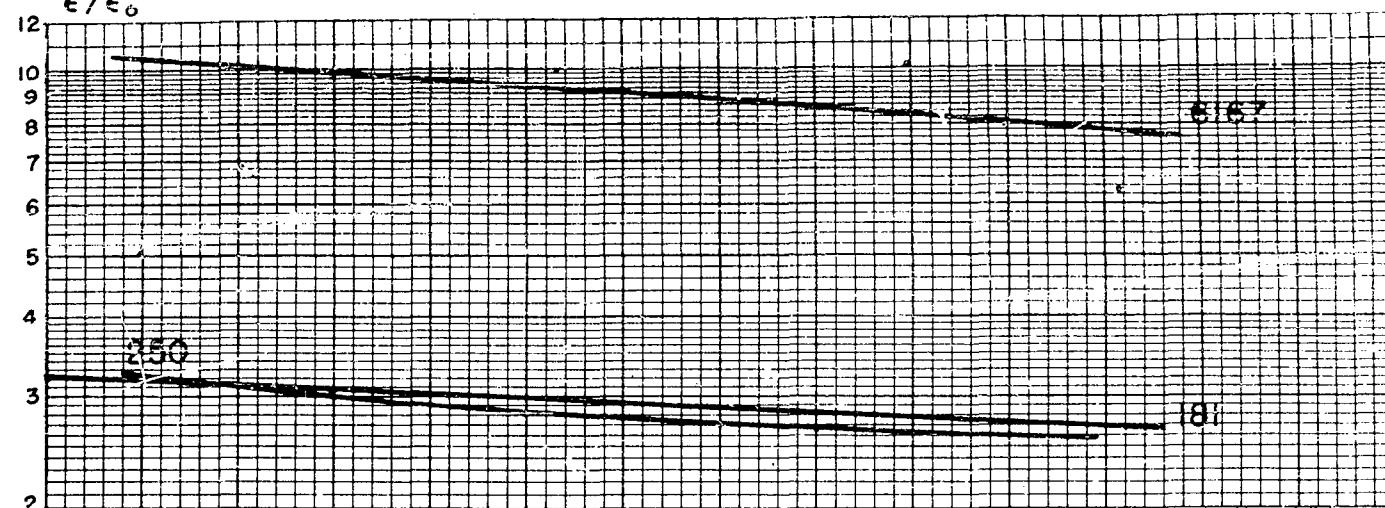
$\tan \delta$



Silicene Rubbers

Silastic 181, 250, 6167
 ϵ'/ϵ_0

Dow Corning



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